Using quantitative forest structure targets: the good, bad, and ugly

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Introduction

- Why?
- Definition
- Quantitative target components
- Washington State's Forests and Fish Law
- Target descriptions
- Target Comparison Part 1: Data
- Target Comparison Part 2: Models
- The good, bad, and ugly

Why is this important?

- Quantitative forest structure targets can:
  - Reduce management uncertainty by clearly specifying the desired forest structure objectives
  - Reduce regulatory uncertainty by clearly specifying the desired forest structure objectives
- With tight financial margins and increasing regulatory pressures it is critical to know what the forest structure objectives are

Definition

- A quantitative target consists of numerical assessment criteria derived from a reference data set selected to represent a desirable outcome or set of conditions that are specified by a distribution of numerical attribute values
- The distribution of attribute values may be used directly or indirectly
  - Direct: Approximate distribution of attributes
  - Indirect: Summary statistics of attributes

Target components

- Target data: A well defined, pedigreed data set that is representative of the desired forest structures used to define assessment criteria
- Observations: actual data or output from a credible forest growth model that are to be assessed relative to the targeted criteria
- Assessment: A statistically and biologically consistent assessment procedure

Target data

- Should
  - be clearly and unambiguously defined
  - be pedigreed: minimum of peer review of sampling and/or analysis methods
  - be representative of desired forest structures
  - be multidimensional to better specify a target
- Why?
  - You're going to derive assessment criteria from them

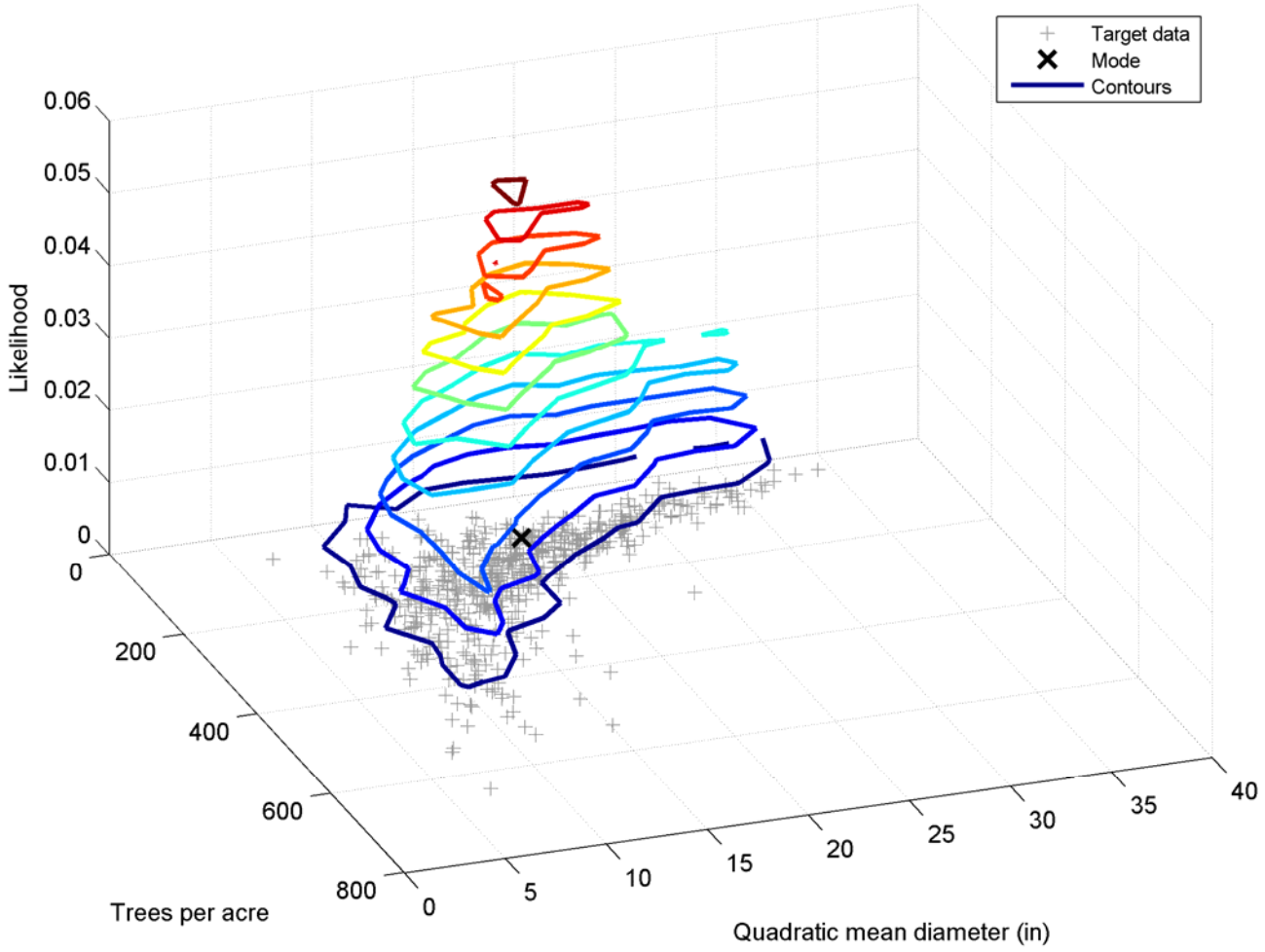
Observations

- Actual measurement data to assess whether management objectives or regulatory criteria have been met on the ground
- Output from a credible forest growth or other model for assessment during planning and management scenario development
  - Credible implies a model that is consistent with reality for the attributes of interest

Assessment

- Statistical consistency
  - Emphasize the distribution, joint distribution for multiple dimensions, of the target data when establishing the assessment criteria
- Biological consistency
  - Use actual data to derive assessment criteria
  - Use relevant attributes
  - Aim for the relevant part of the distribution
  - State-space may be more relevant than attributes *vs*. time

Consistency example



Forests and Fish Law

- Specifies riparian forest management rules for Washington State since 2001
- Different rules for eastern and western Washington
- Focus on western Washington rules
- Defines width of riparian management zone (RMZ) for each side of a stream using Douglas-fir site potential tree height

Forests and Fish Law (cont.)

- Each RMZ is divided into three subzones parallel to a stream
  - A 50 foot wide no harvest zone adjacent to the stream
  - An inner zone where limited harvest *may* be permitted subject to leave tree and other constraints
  - An outer zone where harvest is permitted subject to leave tree and other constraints
- Inner and outer zone widths vary by site class and stream width: < 10 ft or ≥ 10 ft

Forests and Fish Law (cont.)

- Assessments are performed in two steps:
  - Growth model projections of current conditions to an age of 140 years
  - Comparing core and inner zone combined basal area per acre (BAPA) to a threshold at 140 years
    - BAPA < threshold: no inner zone harvest
    - BAPA ≥ threshold: inner zone harvest is permitted provided the residual trees when projected allow the BAPA threshold to be met at 140 years

Forests and Fish Law (cont.)

- Inner zone leave tree requirements:
  - Option 1 (the complicated option): Thin from below, leaving at least 57 TPA (conifer) with DBH ≥12 inches or the largest TPA in the harvested area
  - Option 2 (the less complicated option): Remove trees furthest from the stream first, up to 30 ft (< 10) or 50 ft (≥ 10 ft) from the core zone boundary, leaving at least 20 TPA (conifer) with DBH ≥12 inches or the largest trees in the harvested area

Forests and Fish Law (cont.)

- Outer zone leave tree requirements
  - Option 1: 20 TPA (conifer) with DBH ≥12 inches
    - May be reduced by LWD placement or trees located in channel migration zones on a basal area-for-basal area basis
  - Option 2: 20 TPA (conifer) with DBH ≥12 inches
    - May be reduced to a minimum of 10 TPA (conifer) if the core and inner zones have a projected BAPA surplus at age 140 on a basal area-for-basal area basis

Forests and Fish Law (cont.)

- The BAPA thresholds are referred to as the desired future conditions (DFC) target
- Given the complexity of the rules, a DFC model was created to provide a simple to use tool to perform the assessments
  - The DFC model consists of thousands of growth model runs for a wide variety of initial stand conditions and thinning treatments converted into lookup tables for interpolation

Forests and Fish Law (cont.)

- The initial (interim) DFC BAPA targets were site class dependent
  - Site class I: 285 sq ft per acre
  - Site class II: 275 sq ft per acre
  - Site class III: 258 sq ft per acre
  - Site class IV: 224 sq ft per acre
  - Site class V: 190 sq ft per acre
- Current DFC target
  - One size fits all 325 sq ft per acre

Forests and Fish Law (cont.)

- Initial (interim) BAPA targets were negotiated based on a “found” data set pieced together from several sources
- WA collected its own riparian data set, the DFC validation data set (DFCVDS)
  - To perform hypothesis tests to validate or invalidate the interim BAPA targets
  - To derive alternative BAPA, or other, targets
  - Current BAPA DFC value is the DFCVDS median

Forests and Fish Law (cont.)

- Management objective
  - Create or retain stands that will develop characteristics similar to mature, unmanaged conifer dominated or mixed riparian stands when they reach age 140
- DFCVDS objective
  - Document characteristics of mature, 140 year old, unmanaged conifer and mixed composition riparian stands in western Washington

Data descriptions

- Two target data sets are considered
  - DFCVDS: The conifer dominated riparian forest data collected by Washington State
  - FIAREF: A reference data set for Douglas-fir dominated stands from the FIA IDB v2.0 consistent with the stated sampling objectives of the DFCVDS but emphasizing Douglas-fir
- Both data sets are used to define targets and as observations to be assessed relative to those targets

DFCVDS description

- 113 sample plots
- Targeted age 140: 120 to 160 years (map)
  - Got ages from 80 to 200+ (field)
- Sampled conifer dominated and mixed stands
  - Majority of plots in the Coast and Cascade Ranges
- Filtered sample: potential sample plots removed
  - If they had < 30% canopy closure
  - Or the had conditions unsuitable for tree growth: rock outcrops, talus slopes, landslide scarps or standing water
- Potential for selection bias toward stands with more complete stocking

FIAREF description

- 553 sample plots from FIA IDB v2.0
- Age range from 100 to 180 years
- Douglas-fir dominated stands
  - At least 50% of BAPA Douglas-fir and FIA stand type of Douglas-fir
- Not specifically riparian
  - For gross characteristics likely not an issue
- All plots are not demonstrably untreated
  - Given natural variability, likely not an issue

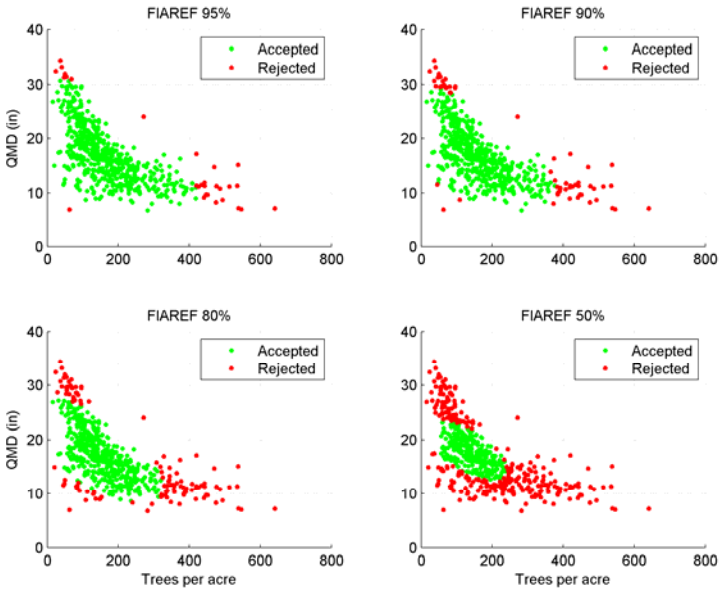
Target types

- Forests and Fish Law minimum BAPA
- Nonparametric targets using approximate joint distribution of TPA and quadratic mean diameter (QMD) for 95%, 90%, 80%, and 50% acceptance regions centered on the mode of the TPA-QMD distribution
- Why TPA-QMD?
  - Used to compute BAPA: separate values avoids size-density issues for equal BAPA

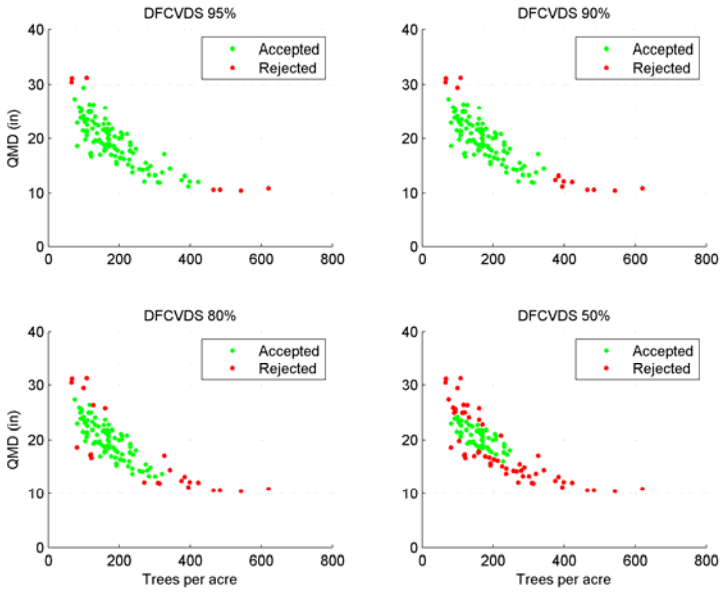
Four targets are compared

- **SI/BA**: Site class dependent BAPA targets
- **OSFA/BA**: One size fits all BAPA target
- **FIAREF**: TPA-QMD Douglas-fir dominated reference condition target from the FIA IDB
- **DFCVDS**: TPA-QMD conifer dominated DFC validation data set target from Washington State

FIAREF Targets



DFCVDS Targets



Caveats

- Apples and oranges comparisons
  - Conifer dominated DFCVDS vs. Douglas-fir dominated FIAREF
- Lowland Douglas-fir zone is typical area of application for Forests and Fish Law
  - Hence Douglas-fir site classes in Forests and Fish Law, but applied across conifer species
- Use of DFCVDS and BAPA targets here is consistent with that of Washington State

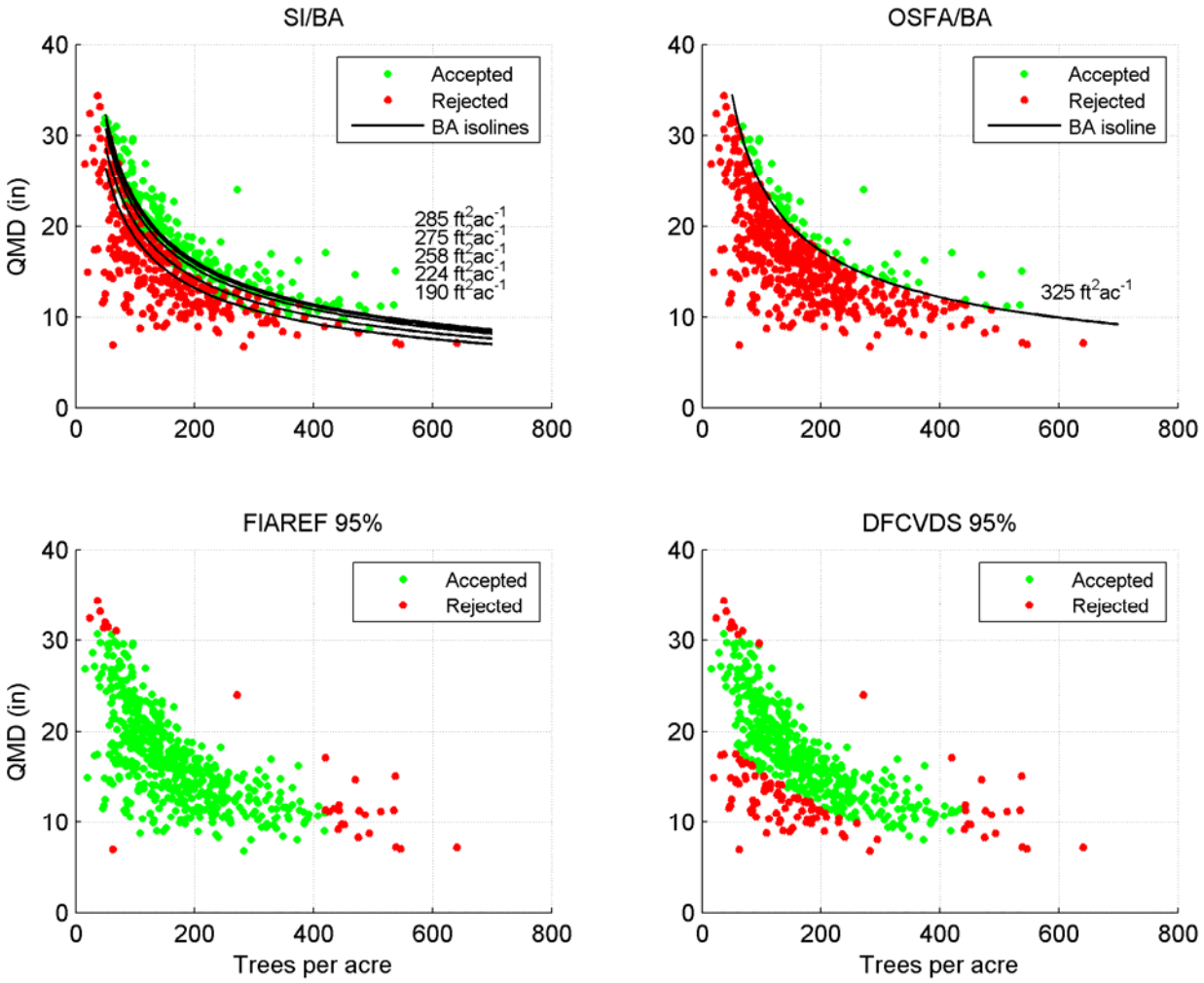
Comparison part 1: Data

- Assess each data set against each target
- Compute an acceptance percentage for each data set, target, and acceptance level
- Compare assessments
  - Look for statistical and biological consistency
  - Potential bias

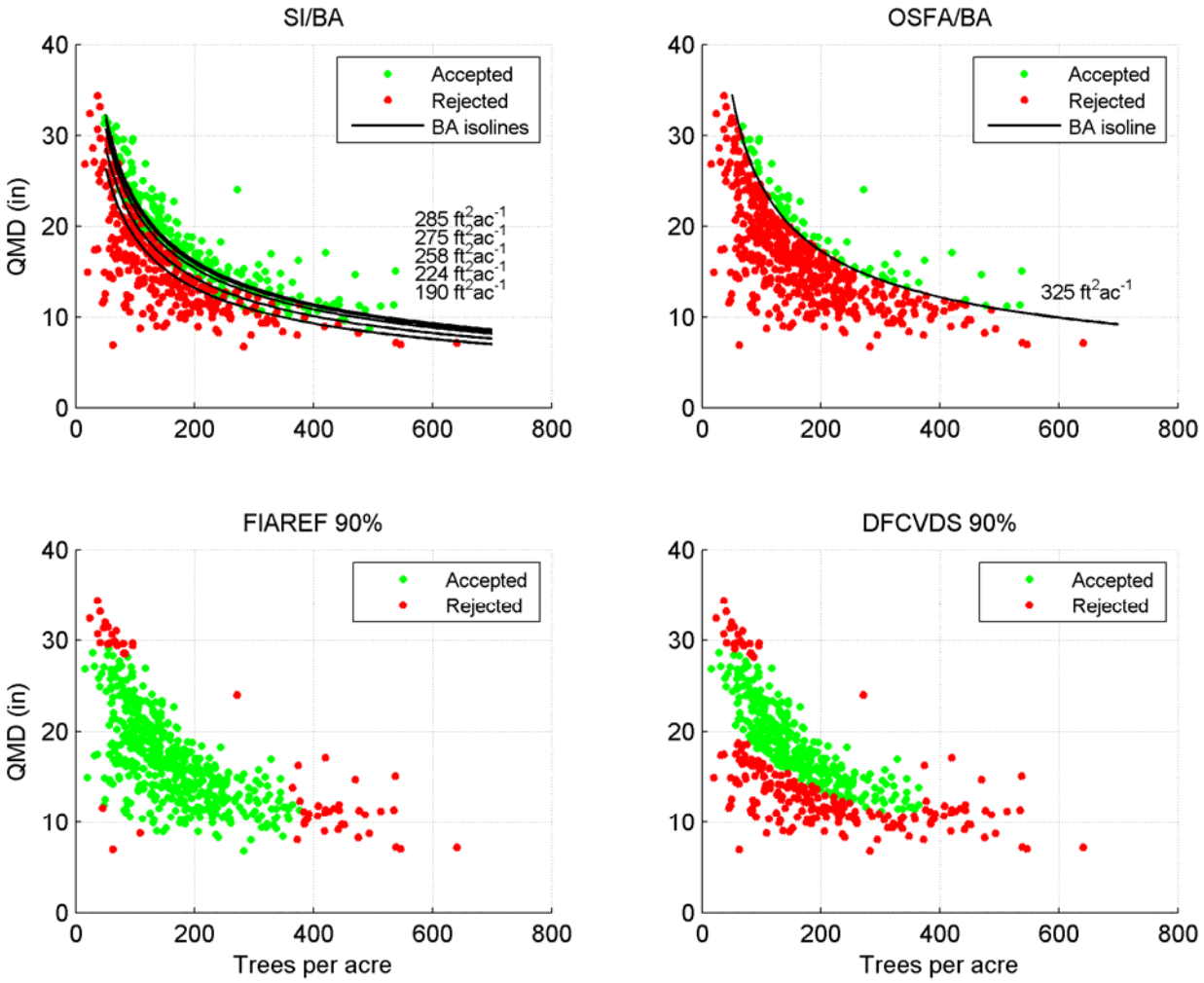
FIAREF assessment results

Target Name	95%	90%	80%	50%
SI/BA	47%	47%	47%	47%
OSFA/BA	13%	13%	13%	13%
FIAREF	95%	90%	80%	50%
DFCVDS	80%	61%	51%	20%

FIAREF 95 %


SI/BA
Accepted
Rejected
BA isolines
285 ft²ac⁻¹
275 ft²ac⁻¹
258 ft²ac⁻¹
224 ft²ac⁻¹
190 ft²ac⁻¹
QMD (in)
OSFA/BA
Accepted
Rejected
BA isoline
325 ft²ac⁻¹
FIAREF 95%
Accepted
Rejected
QMD (in)
Trees per acre
DFCVDS 95%
Accepted
Rejected
Trees per acre

FIAREF 90%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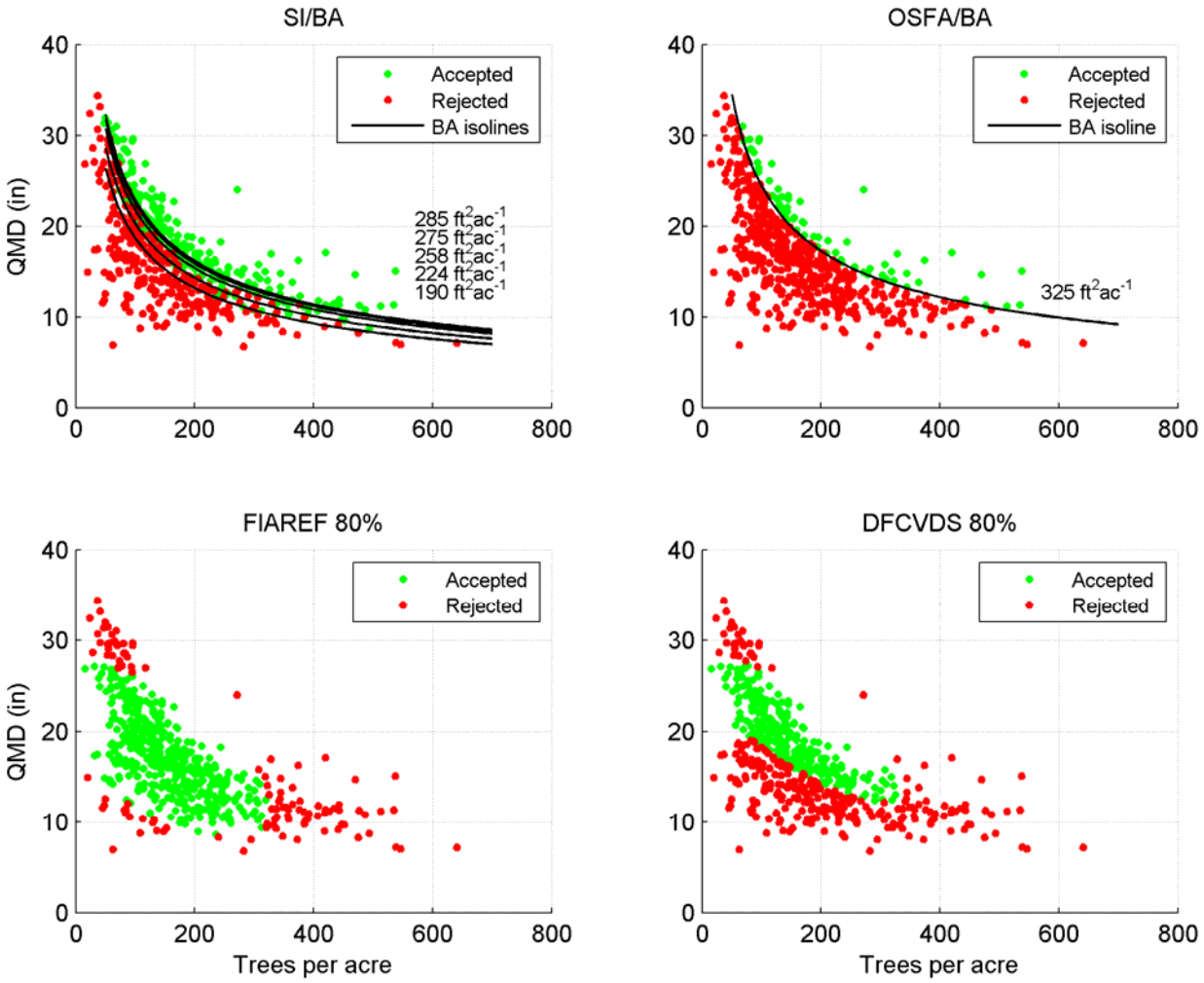
FIAREF 90%
Accepted
Rejected
DFCVDS 90%
Accepted
Rejected
QMD (in)
Trees per acre
0
10
20
30
40
200
400
600
800

FIAREF 80%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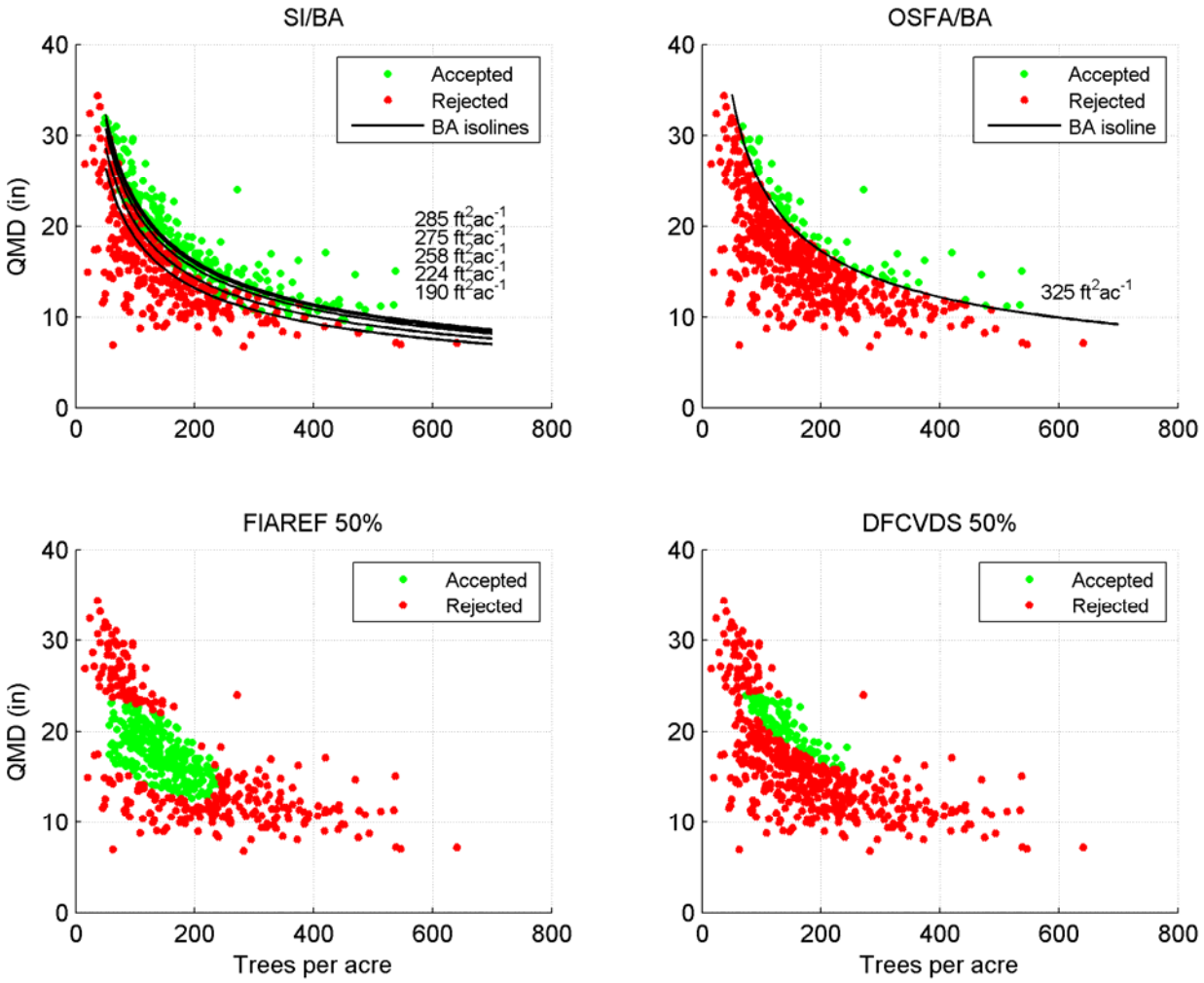
FIAREF 50%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DFCVDS 50%
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QMD (in)
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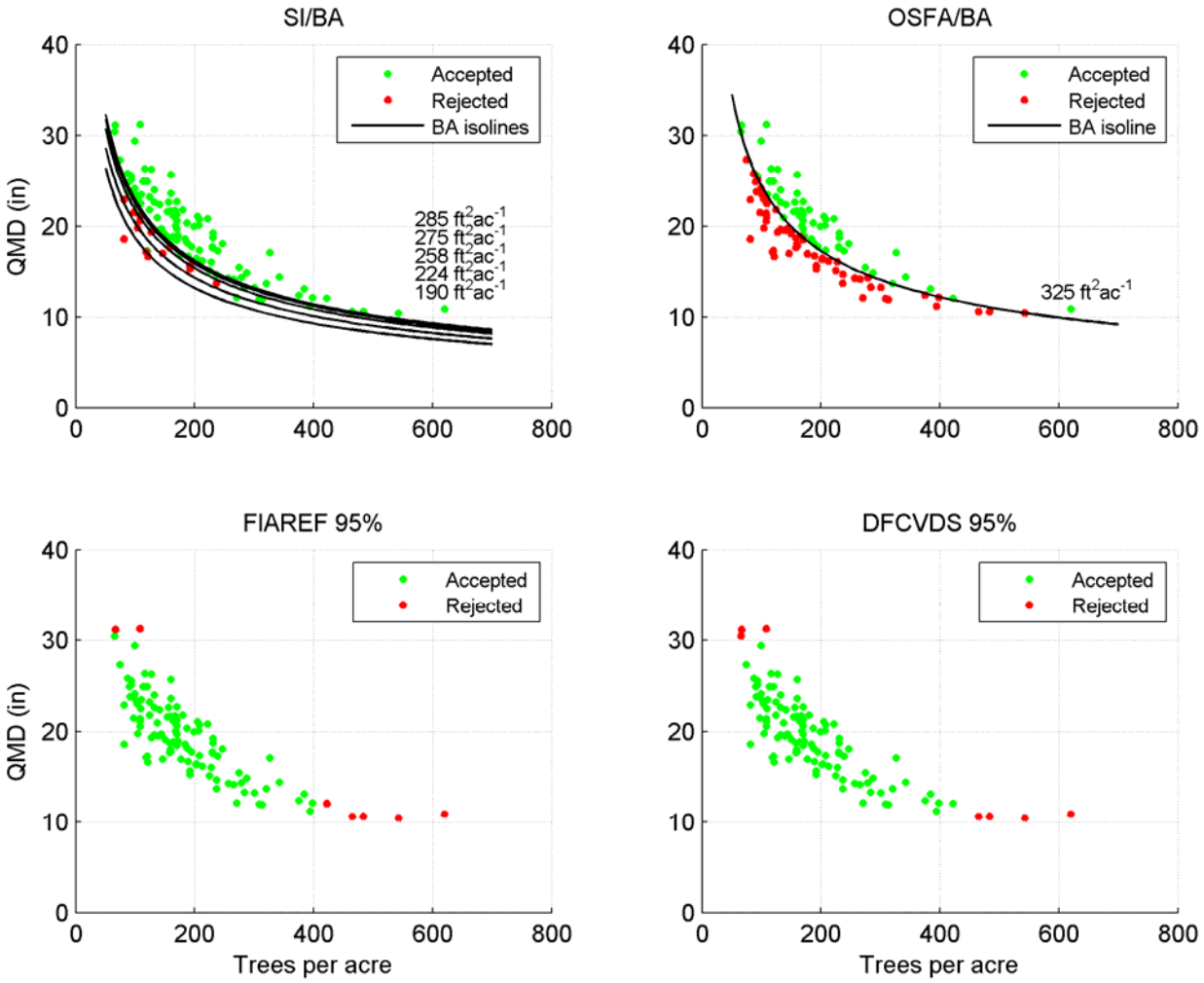
DFCVDS assessment results

Target Name	95%	90%	80%	50%
SI/BA	88%	88%	88%	88%
OSFA/BA	50%	50%	50%	50%
FIAREF	94%	88%	83%	39%
DFCVDS	94%	88%	79%	49%

DFCVDS 95%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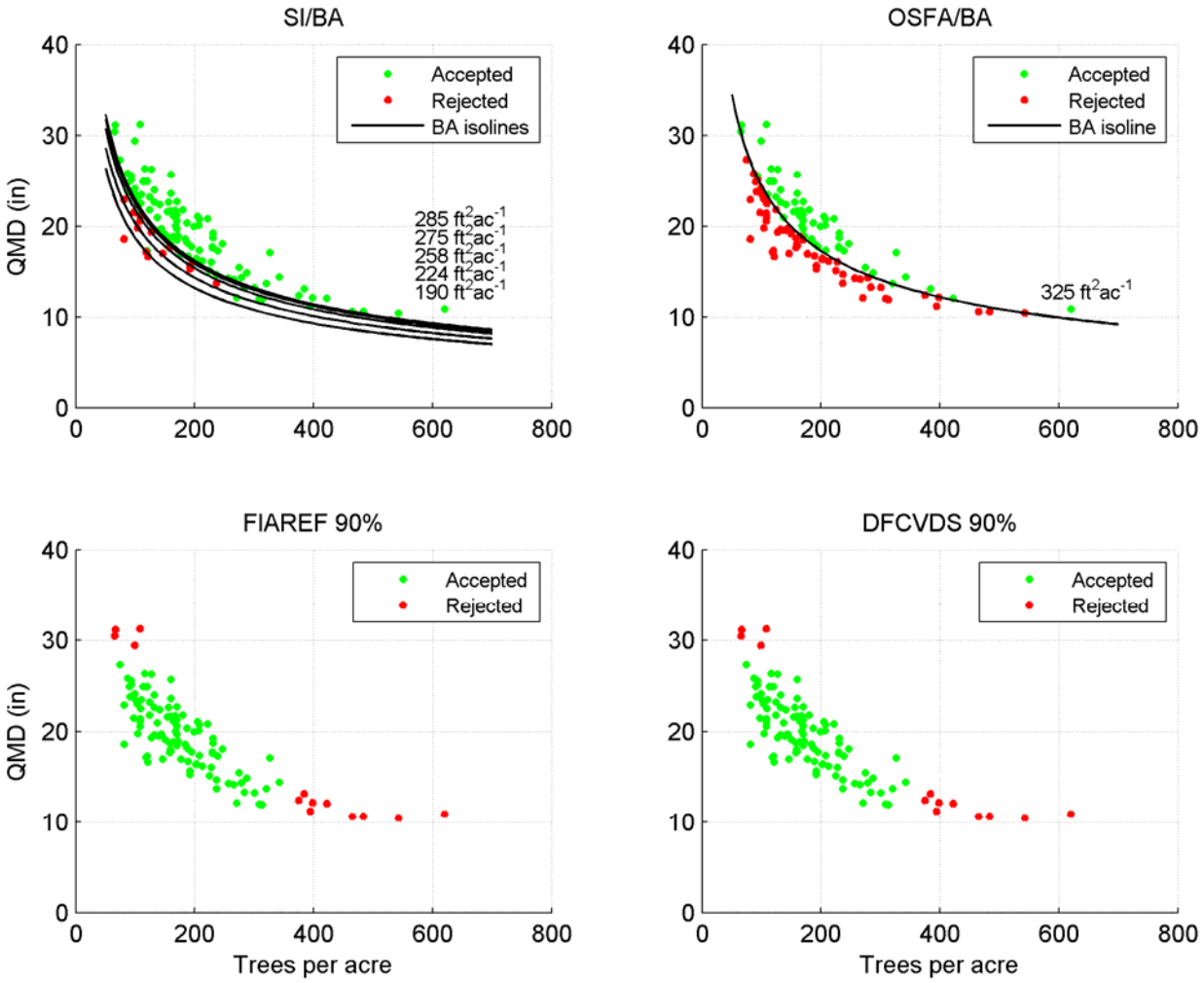
DFCVDS 90%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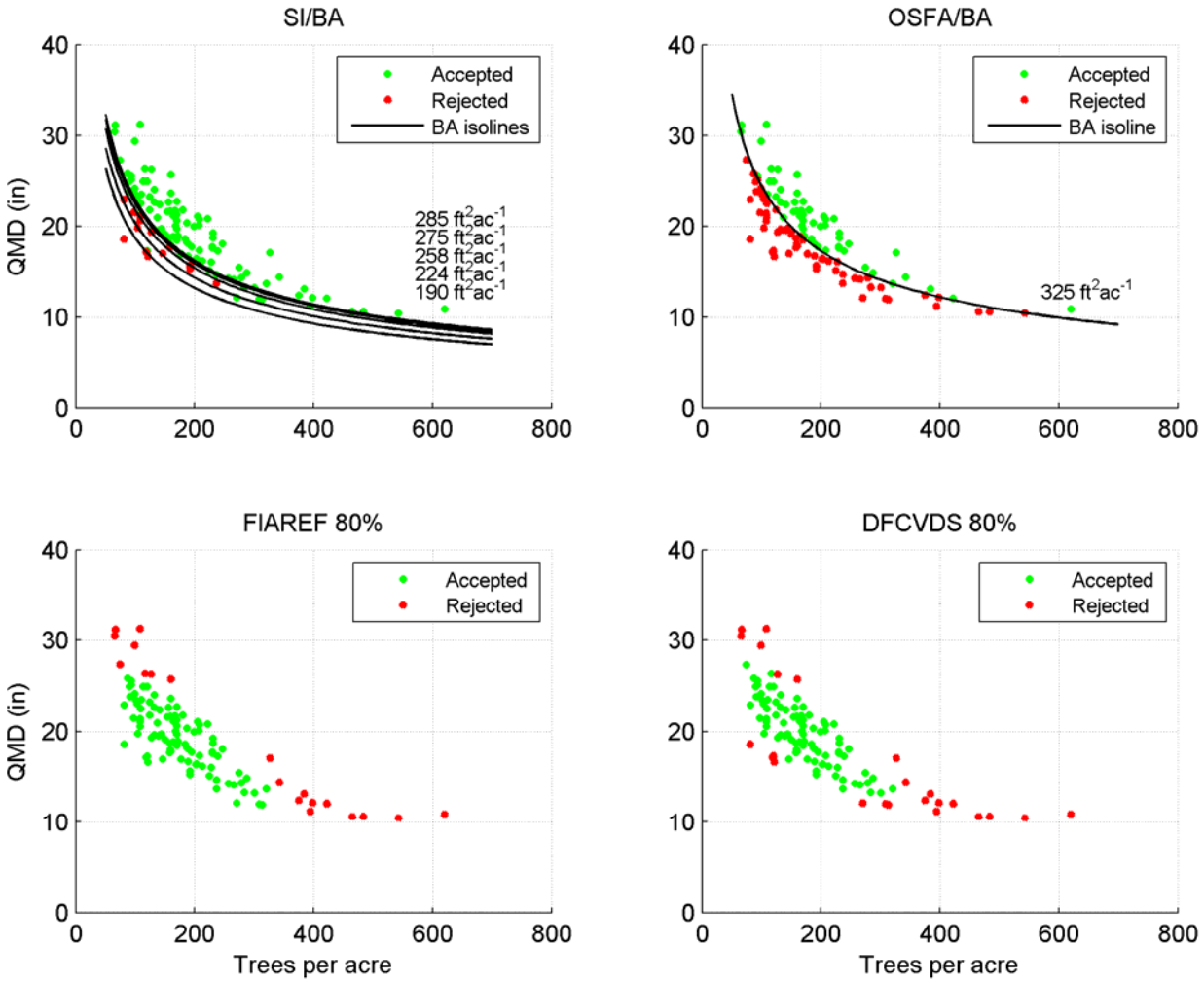
DFCVDS 80%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QMD (in)
Trees per acre
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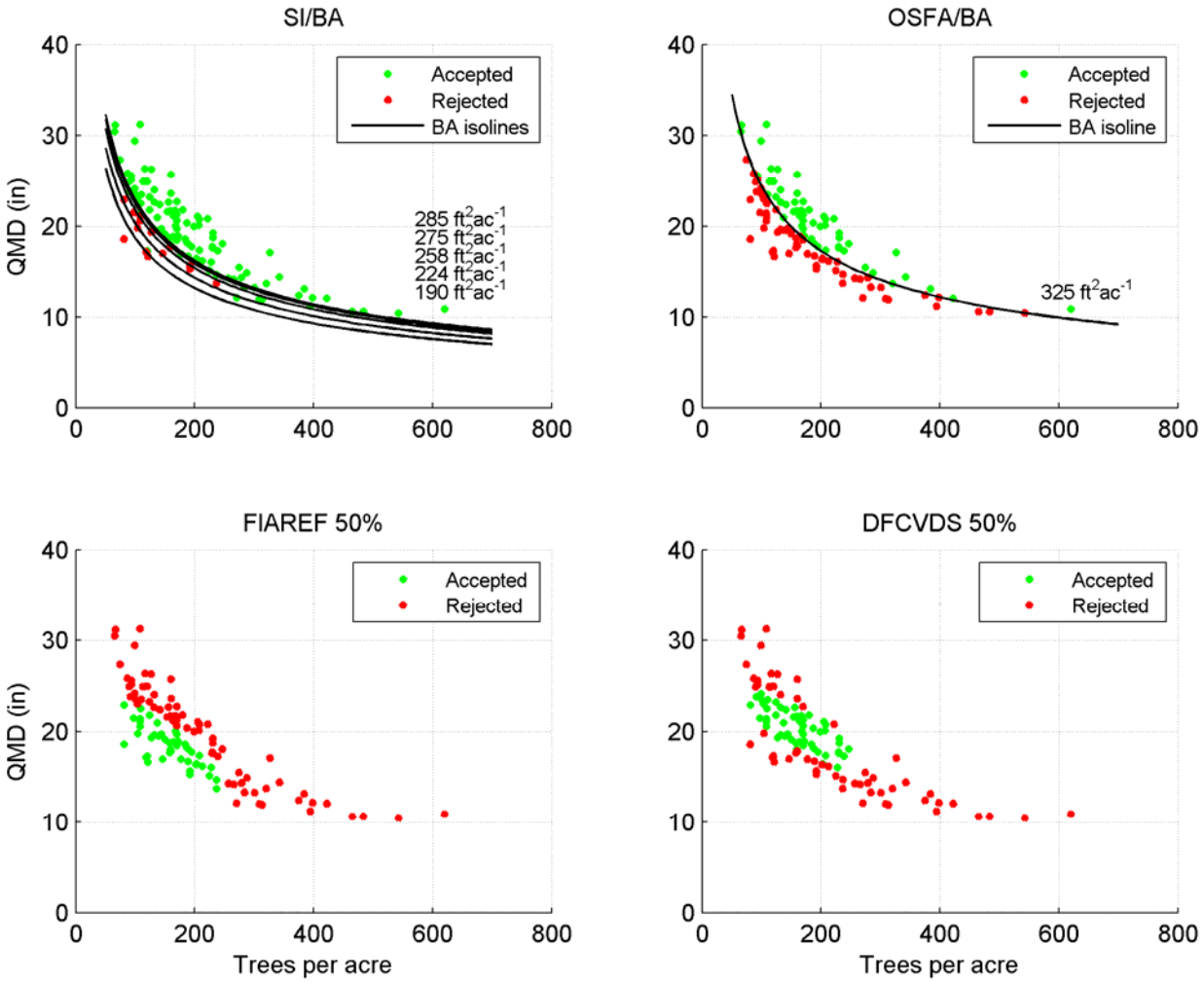
DFCVDS 50%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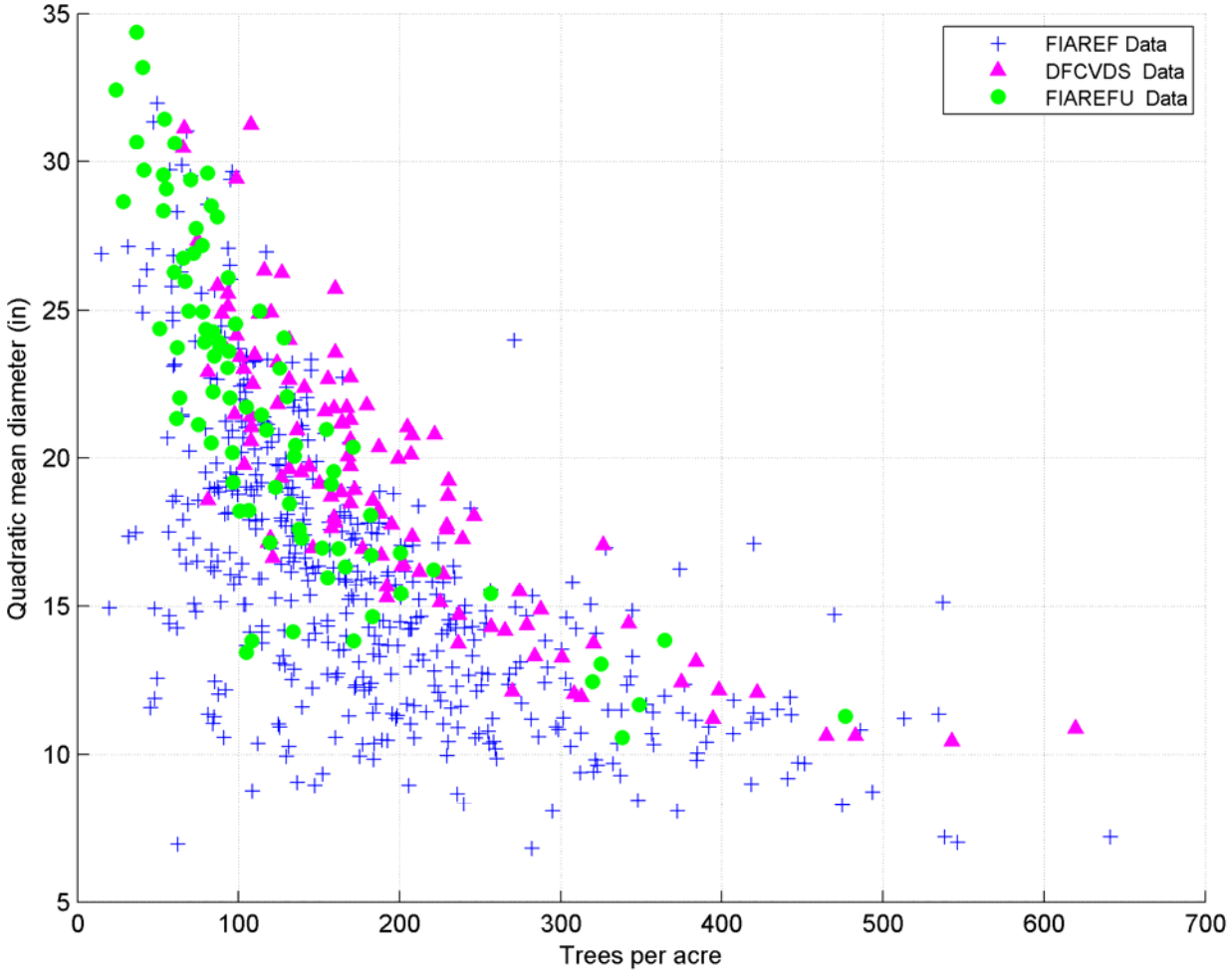
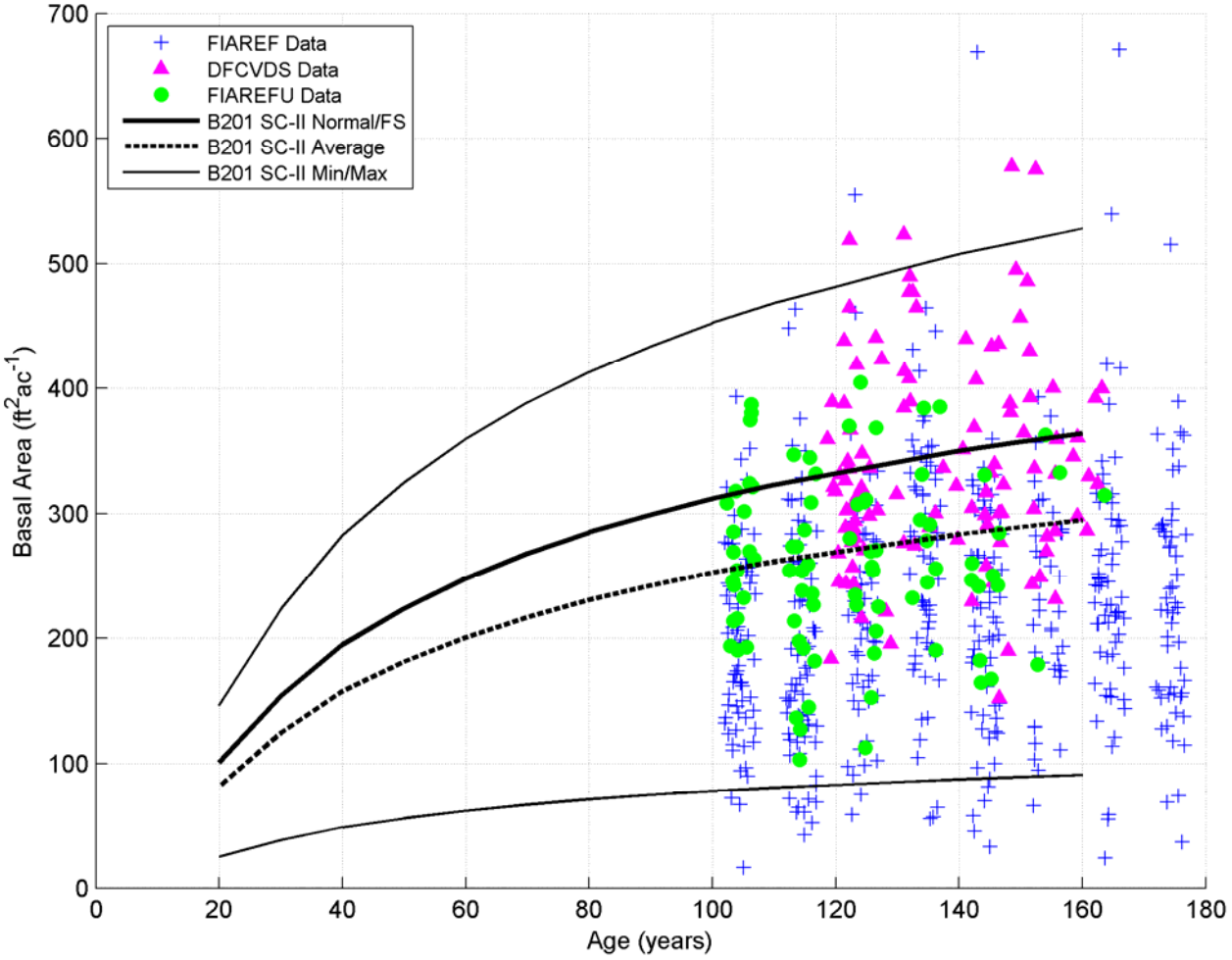
Data: Potential bias

- Issues to consider
  - Conifer vs. Douglas-fir stands
  - Riparian vs. upland stands
  - Untreated vs. manipulated stands
- Compare with historic reference: Bulletin 201
  - McArdle, R.E., Meyer, W.H., and D. Bruce. 1949, 1961. The yield of Douglas-fir in the Pacific Northwest. Washington, DC. USDA Forest Service Tech. Bul. No. 201. 72 p. (rev.)

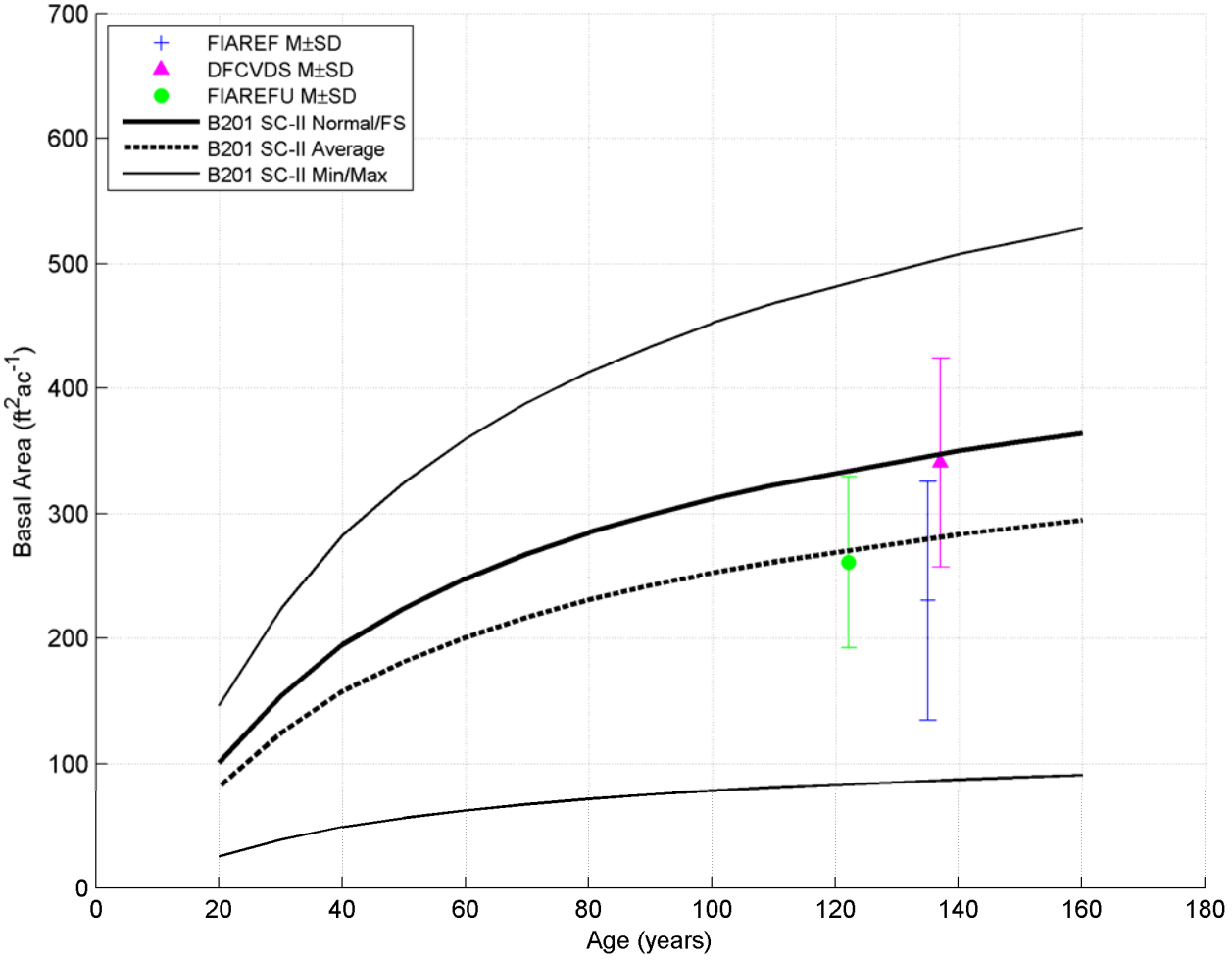
Data: scatter plot



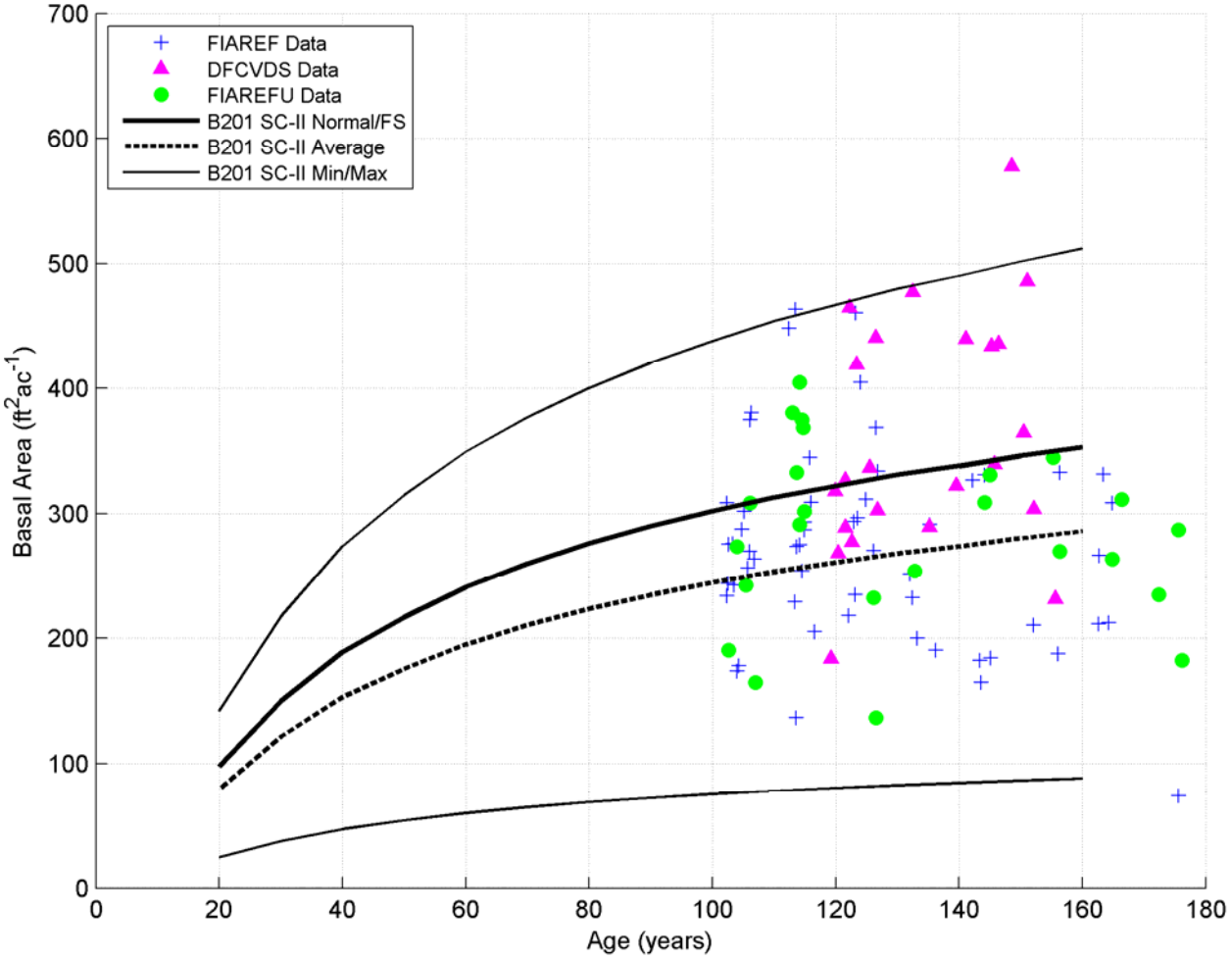
Data: BAPA all stands



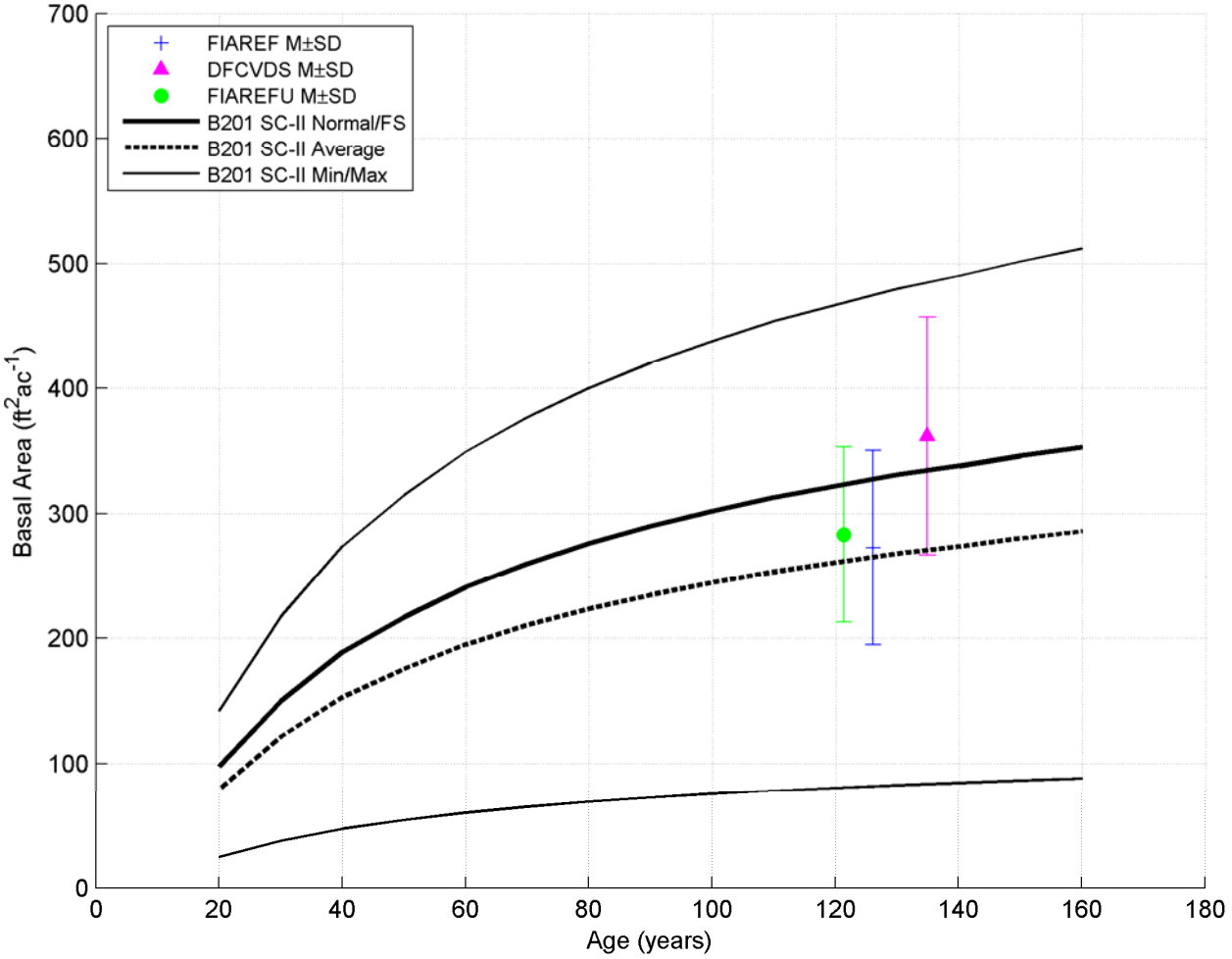
Data: BAPA summary all stands



Data: BAPA SC-II



Data: BAPA summary SC-II



Comparison part 2: Models

- Project five management scenarios with two growth models
- Compute assessments and acceptance percentages for each target and model
- Acceptance level of 90% for 2-D targets
- Compare assessments
  - Look for statistical and biological consistency
  - Potential bias

Models used

- ORGANON-SMC V 6.0
  - Model used to create the DFC Model assessment tool
- ORGANON-SMC 8.x (8.2 used here)
  - New version initially released November 2005
  - New diameter growth, height growth, and mortality equations for Douglas-fir and western Hemlock
- Models used “out of the box”

Management scenarios

- Douglas-fir dominant/pure stands
- Site Class II: 119-137 feet at 50 years
- Scenarios
  - 50 foot no harvest with 50 year rotation
  - Bio-Pathway (produces multistory canopy)
  - Forest and Fish Option 2 ≥ 10 feet
  - Forest and Fish Option 2 < 10 feet
  - No action

Forests and Fish Law

- RMZ definition
  - Core: 0-50 feet
  - Inner:
    - 50-114 feet for stream width < 10 feet
    - 50-120 feet for stream width ≥ 10 feet
  - Outer: 114 or 120 to 170 feet
- Option 2 (the simple option)
  - Increases no harvest buffer to 80 or 100 feet for stream widths < 10 feet or ≥ 10 feet
- Minimum BAPA
  - 275 ft^2ac^{-1} for SI/BA (initial rules)
  - 325 ft^2ac^{-1} for OSFA/BA (current rules)

Initial conditions/Treatments

- 471 TPA planted Douglas-fir stand
- 20 years old
- Site index 120 feet at 50 years
- Located in southwest Washington
- Treatments
  - Do nothing
  - 50 year rotation with multiple thinnings
  - Multiple thinnings with underplanting
  - 10 and 20 TPA leave tree 50 year rotations

Results: Forest and Fish Law

Target	SI/BA age 140		OSFA/BA age 140	
Model	O6.0	O8.2	O6.0	O8.2
50 ft no harvest	Yes	No	No	No
Bio-Pathway	Yes	No	No	No
FF Option 2 ≥ 10	Yes	Yes	Yes	No
FF Option 2 < 10	Yes	Yes	Yes	No
No Action	Yes	Yes	Yes	Yes

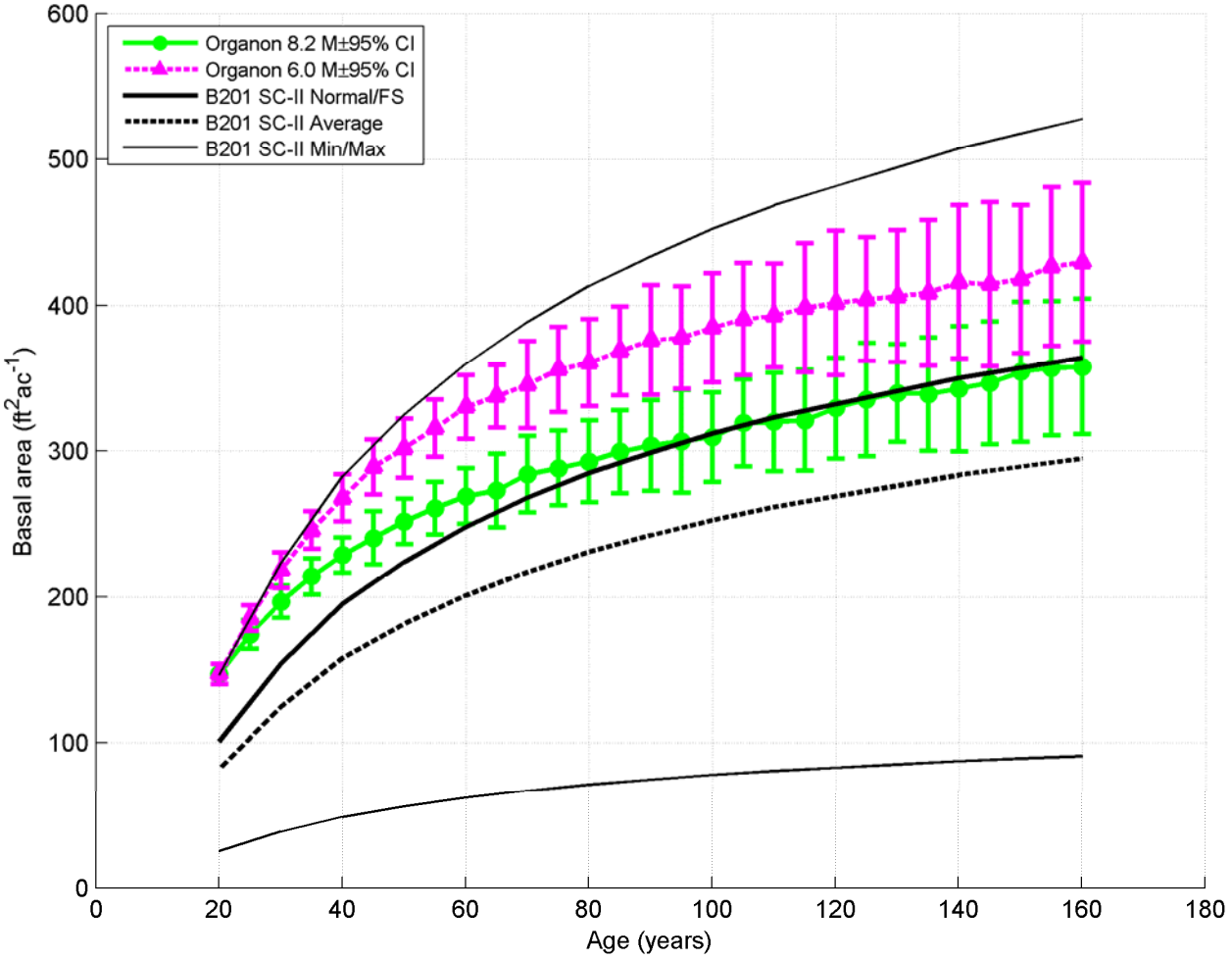
Results: TPA-QMD Target 90%

Target	FIAREF		DFCVDS	
Model	O6.0	O8.2	O6.0	O8.2
50 ft no harvest	100%	100%	38%	34%
Bio-Pathway	100%	100%	34%	21%
FF Option 2 ≥ 10	100%	100%	79%	72%
FF Option 2 < 10	100%	100%	69%	55%
No Action	83%	83%	83%	83%

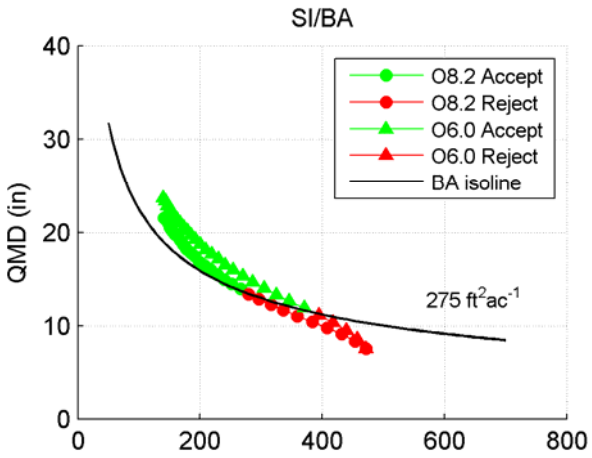
Models: Potential bias

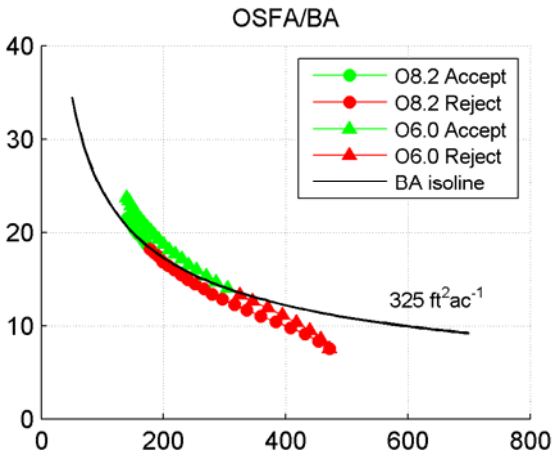
- Issues to consider
  - Model bias
  - State space vs. time-attribute trajectories
- Compare with historic reference: Bulletin 201:
  - McArdle, R.E., Meyer, W.H., and D. Bruce. 1949, 1961. The yield of Douglas-fir in the Pacific Northwest. Washington, DC. USDA Forest Service Tech. Bul. No. 201. 72 p. (rev.)

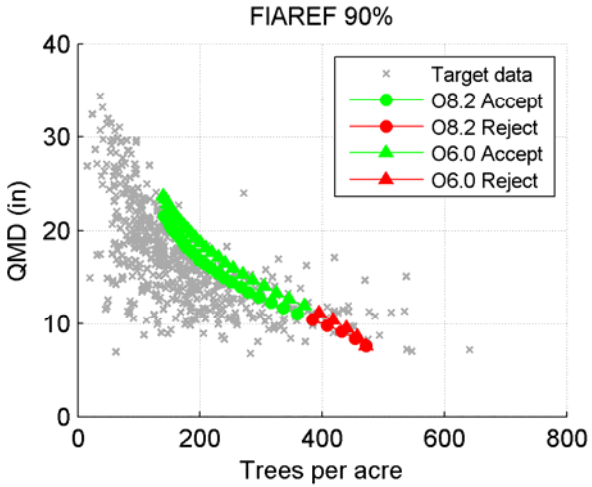
Time-Attribute Trajectory

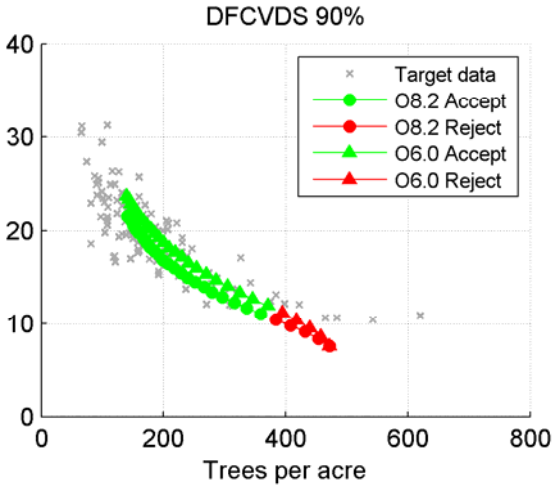


State space trajectory





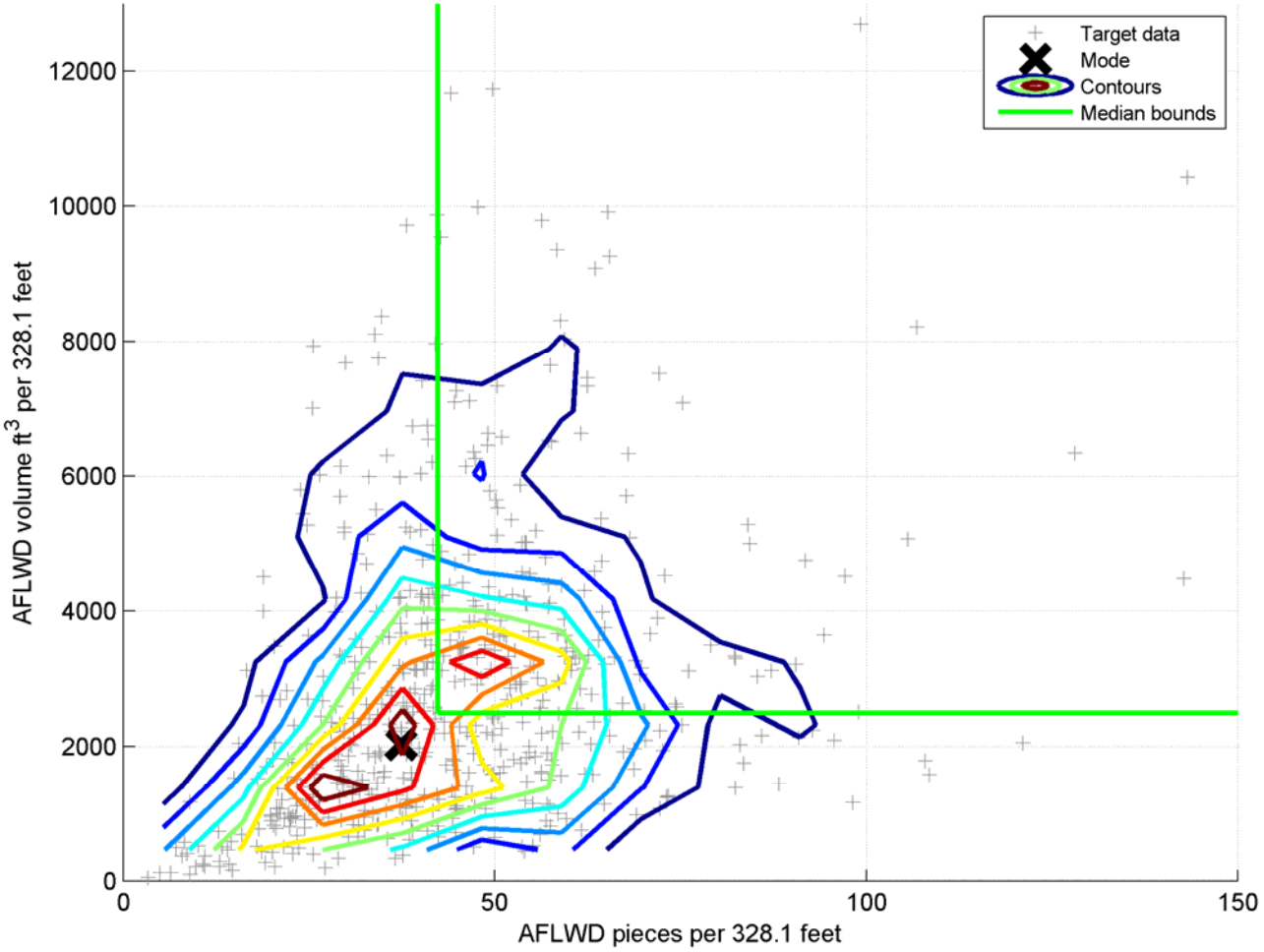




Relevant attributes

- Why use BAPA as surrogate for riparian forest function?
  - Tree size, distance to stream are most relevant
- What about an estimate of large woody debris supply from the adjacent forest?
  - Two components: pieces and volume
- Proposed target (not by me!)
  - Box constraints using median values as minimums
  - Excludes mode of distribution

Large woody debris supply



The good

- Using quantitative targets
- Multidimensional targets/joint distribution
- Statistically and biologically consistent assessment methods
- Using attributes directly related to problem of interest, if available, rather than correlated surrogates

The bad

- Using weakly correlated surrogate attributes
- Biased data sets or models
- Single value lower bounds
- Inappropriate lower bounds, e.g., median values

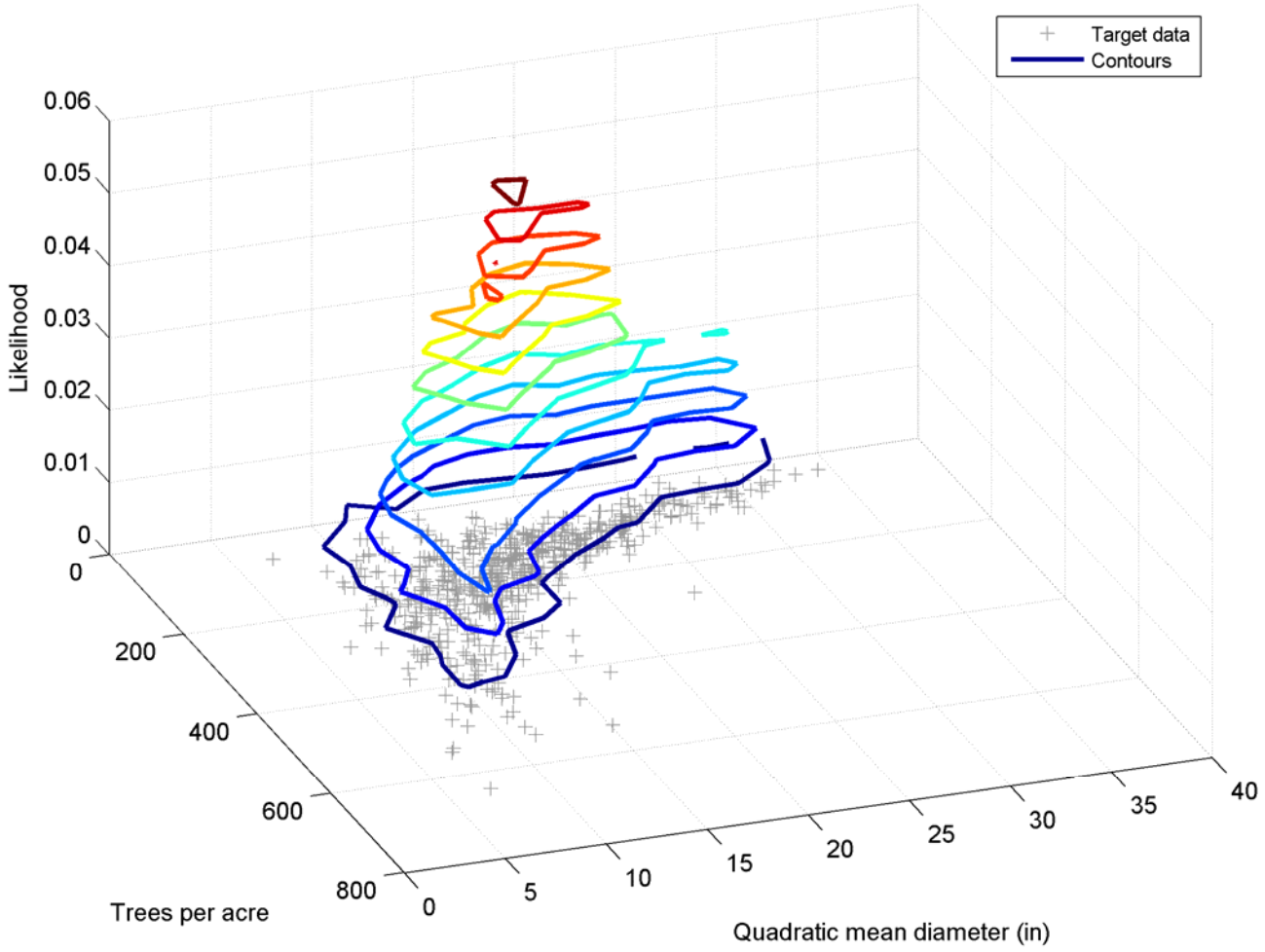
The ugly

- Leaving the mode out of an acceptance region
- Marginal distribution based box constraints
- Single point in time assessments
- Difficult to maintain assessment tools
- Complex rules with little direct scientific justification for the complexity

Take home messages

- Be sure your data represent what you want or say you want to target
- Be sure the output from models you use is close enough to reality to be useful
- Be sure to select relevant attributes
- Be sure to use statistically and biologically consistent assessment methods

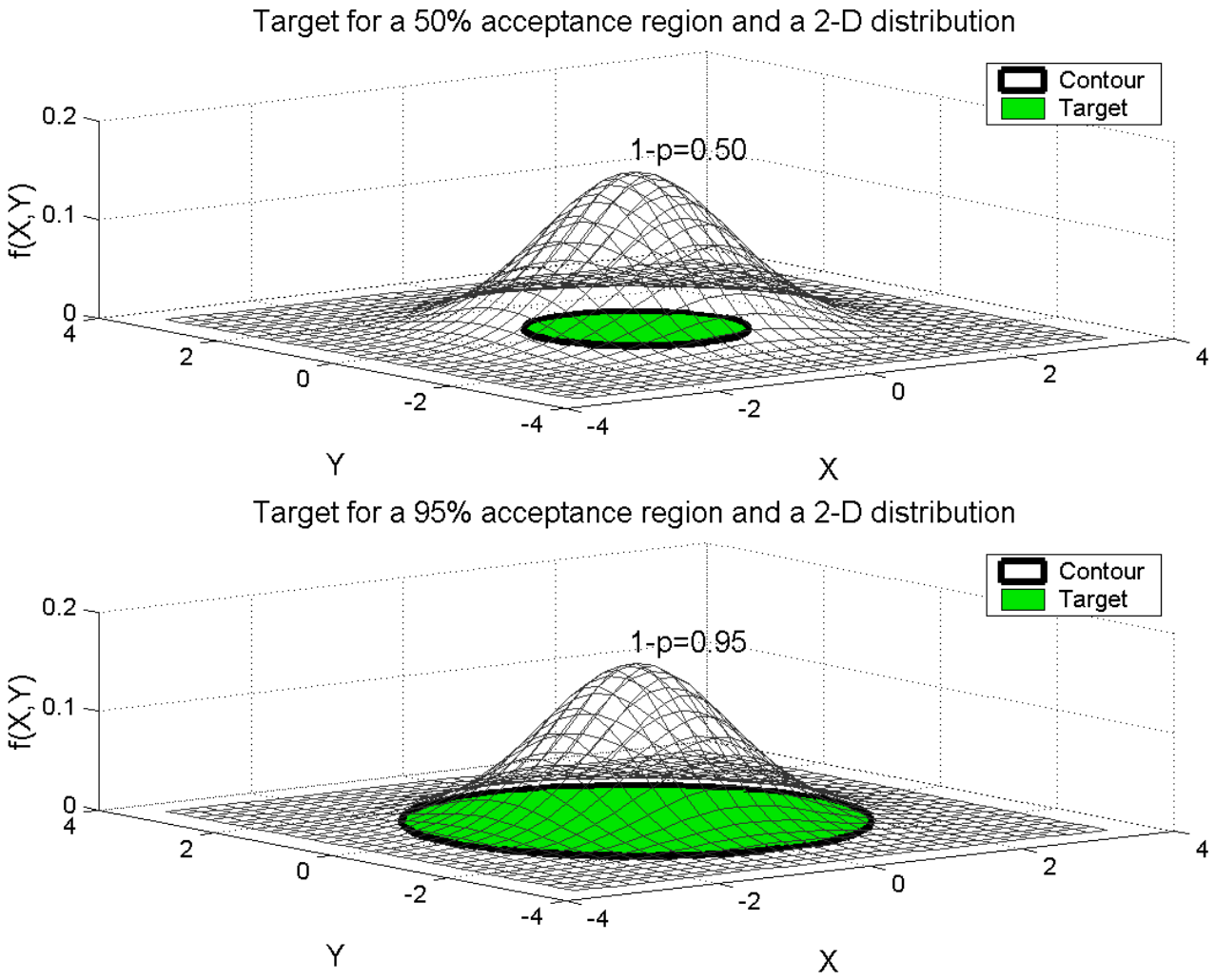
Consistency example



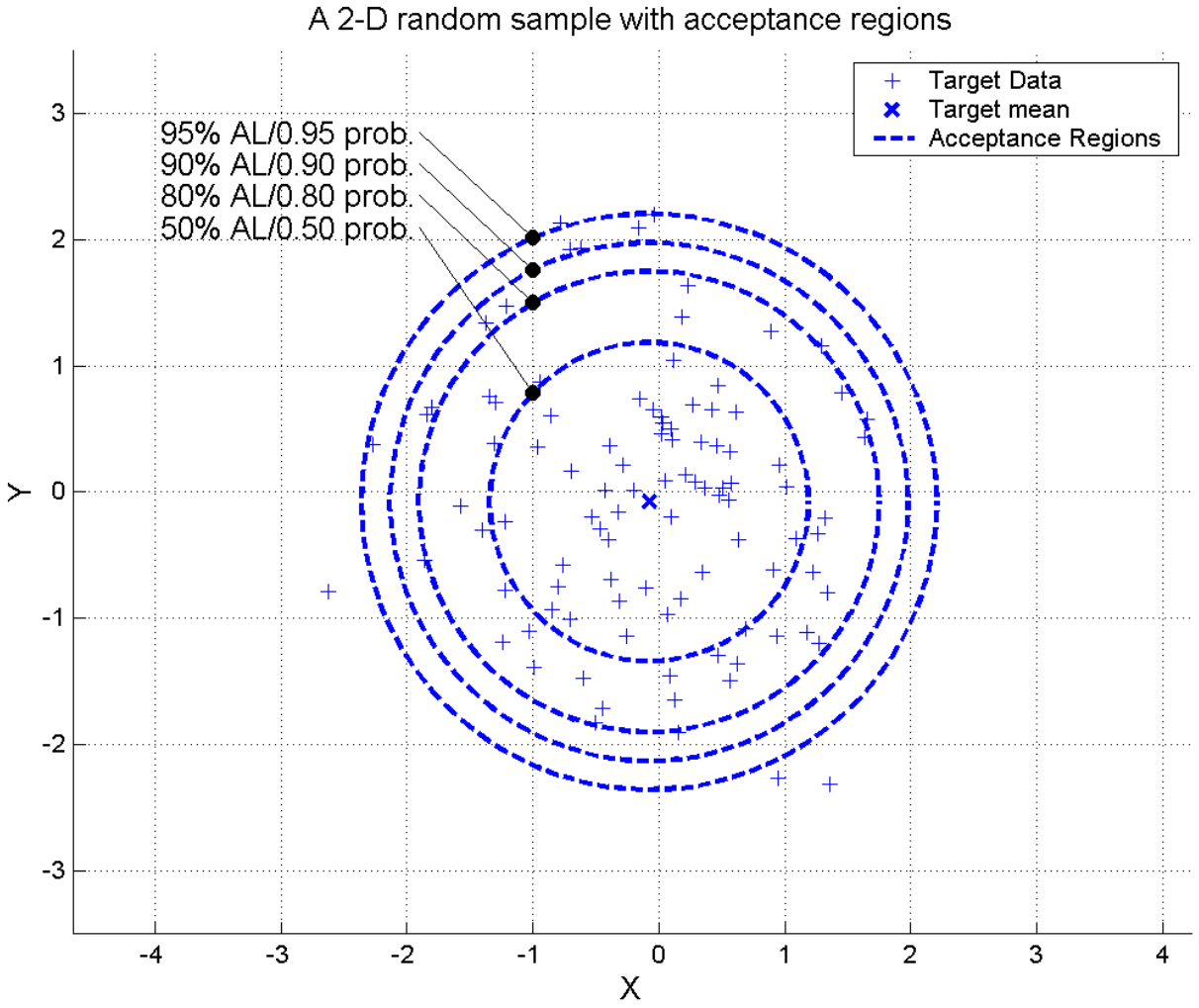
Target types

- Two types of targets considered
  - Minimum BAPA as in Forests and Fish Law
  - Multivariate, nonparametric targets using approximate joint distribution of TPA and quadratic mean diameter (QMD) for 95%, 90%, 80%, and 50% acceptance regions centered on the mode of the TPA-QMD distribution
- Interested in investigating statistical and biological consistency of targets

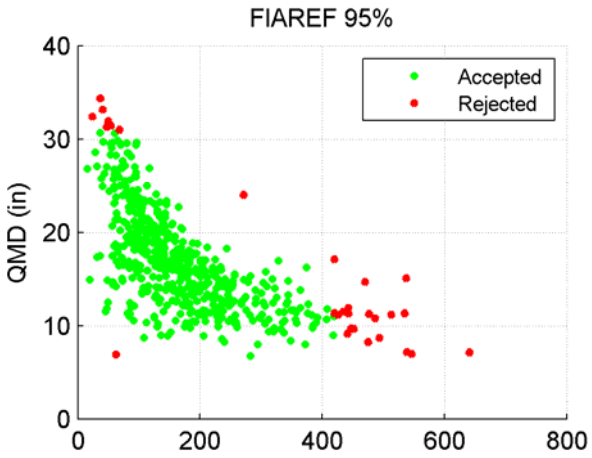
Multivariate target

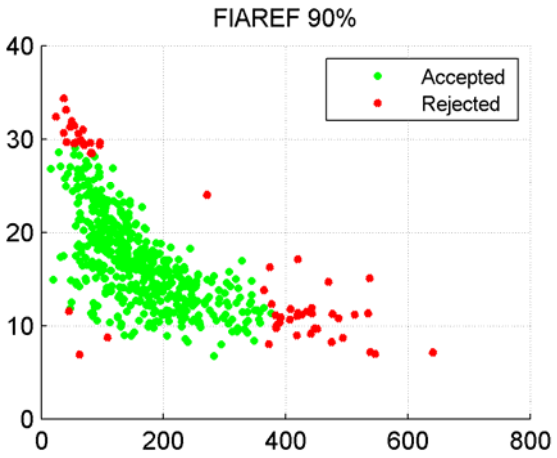


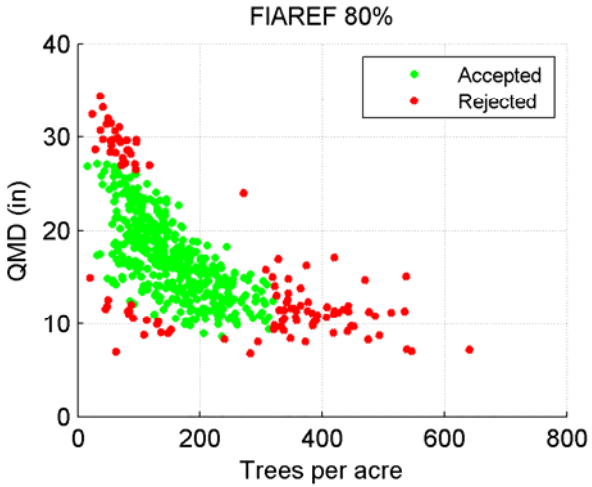
Nonparametric target

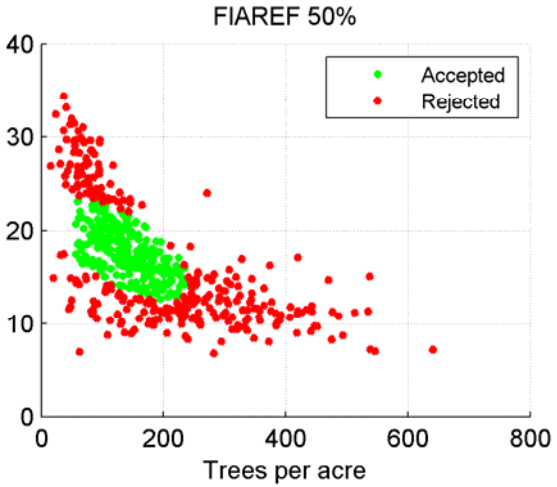


FIAREF targets

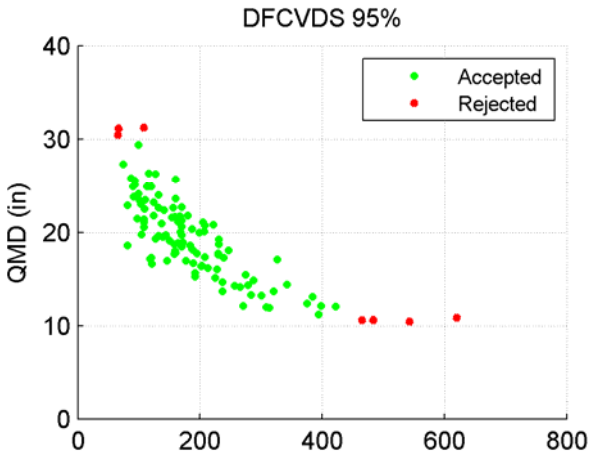


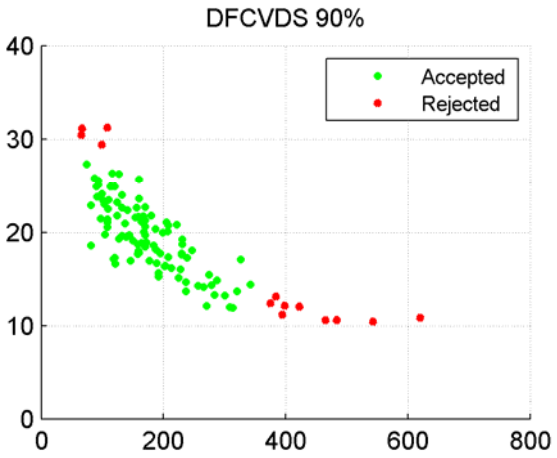


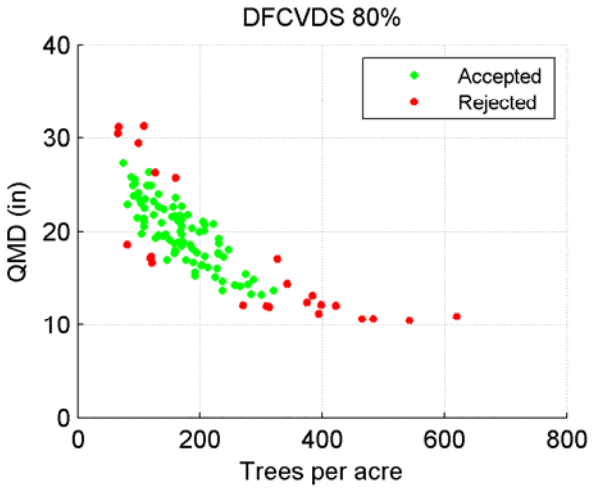


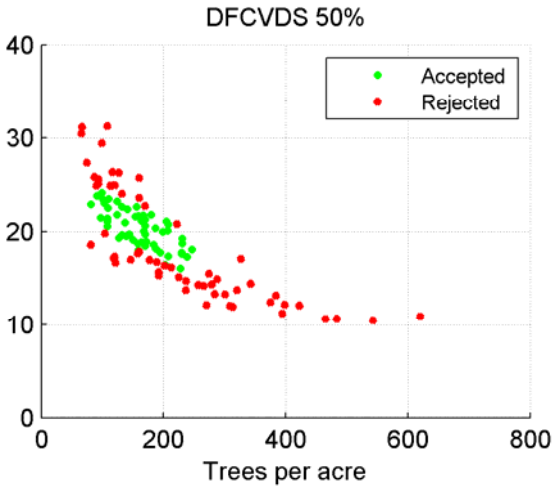


DFCVDS targets

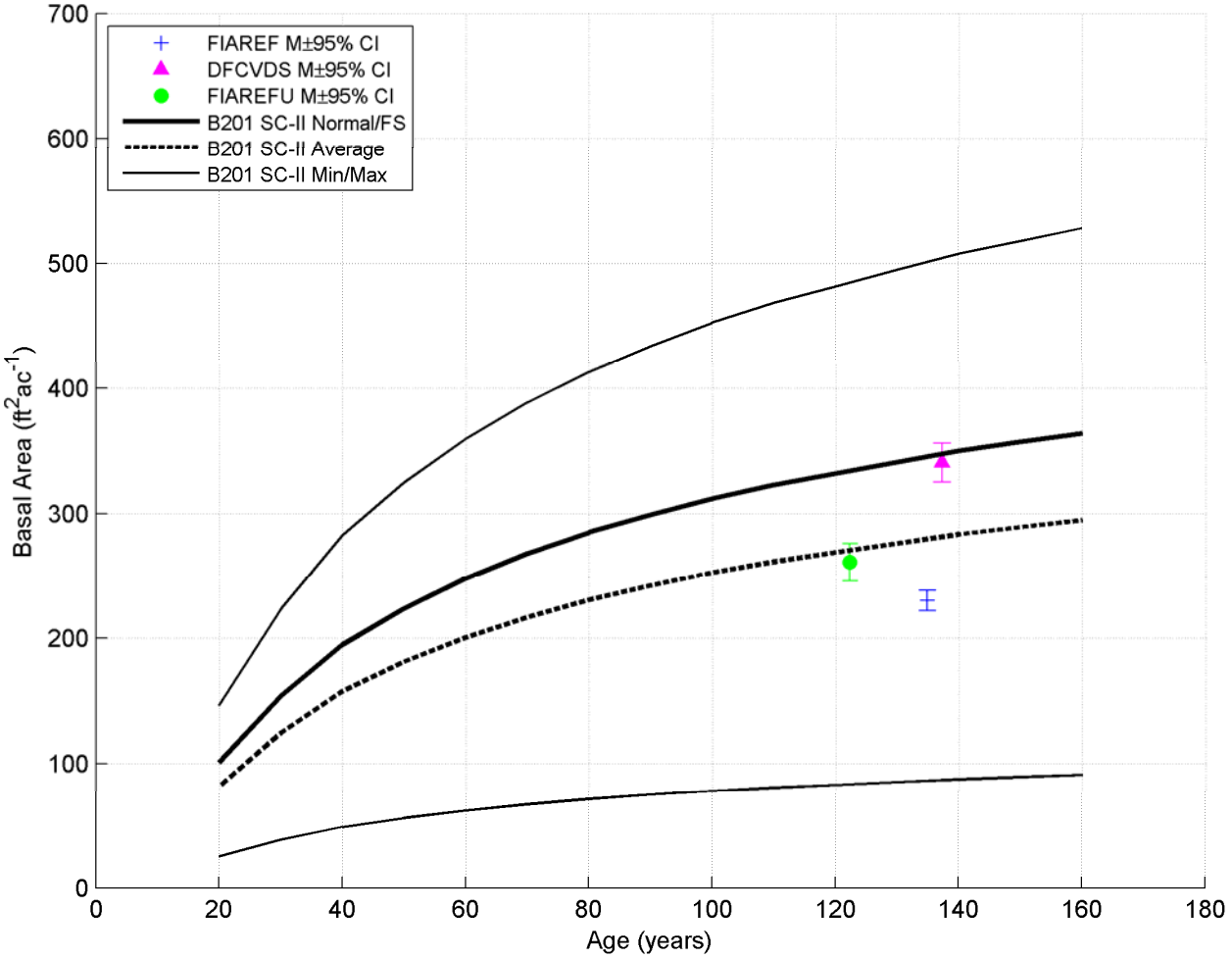




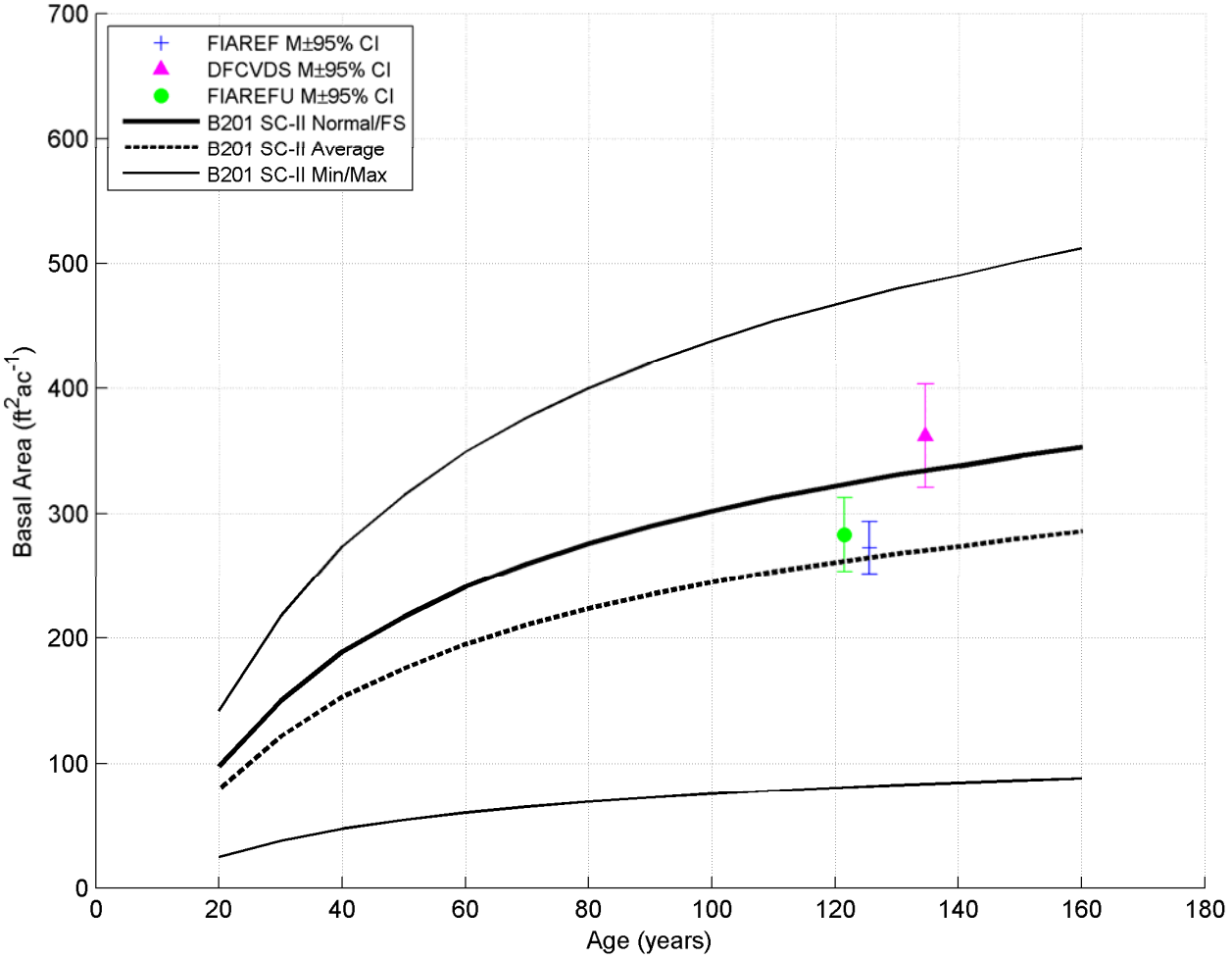




Data: BAPA summary all stands

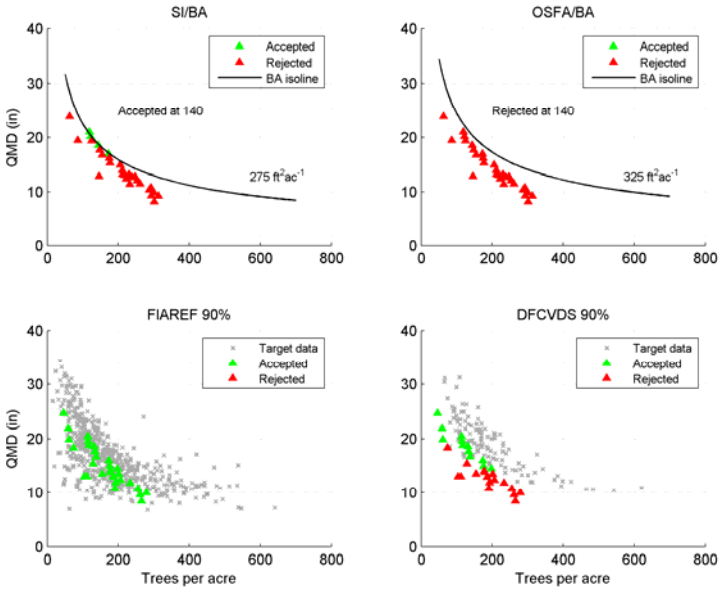


Data: BAPA summary SC-II

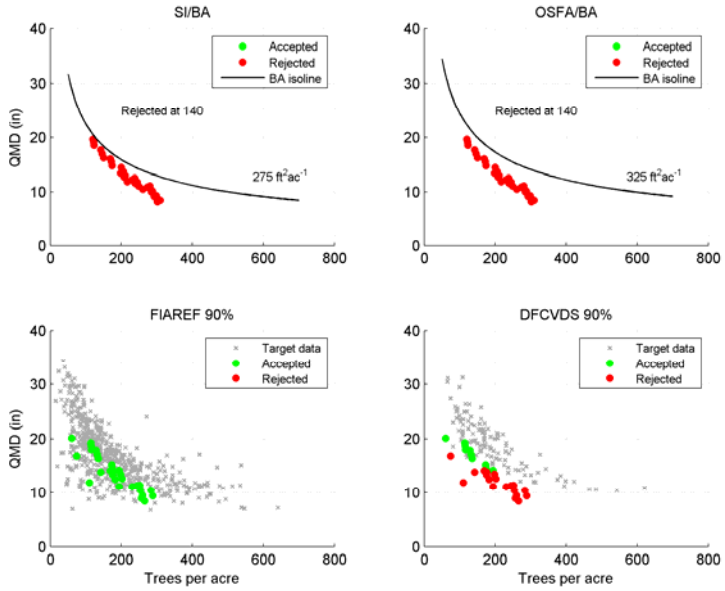


50 ft no harvest

O6.0

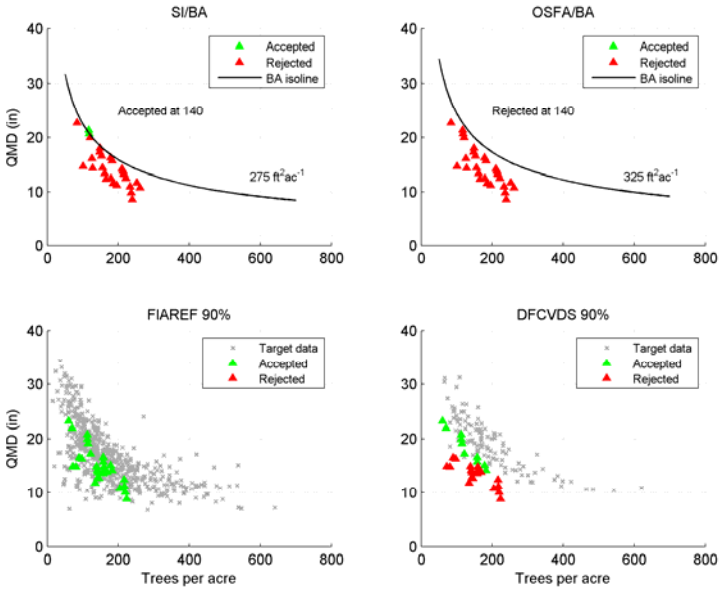


O8.2

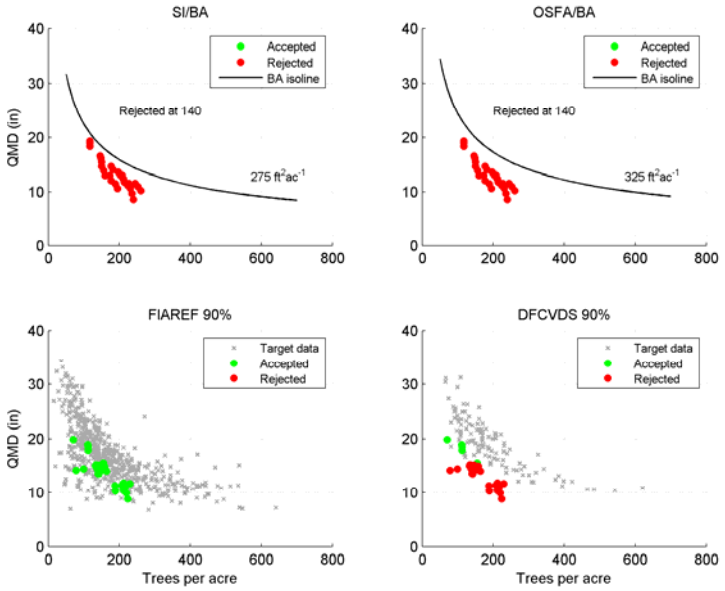


Bio-pathway

O6.0

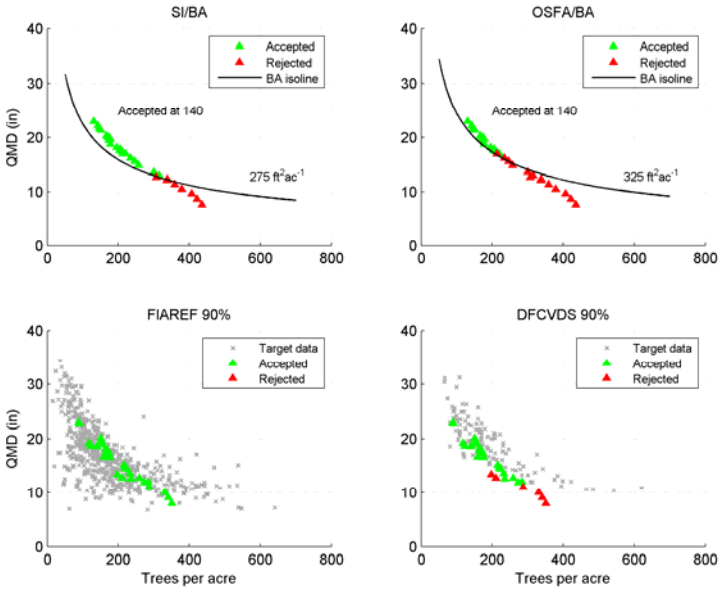


O8.2



FF Option 2 ≥ 10

O6.0



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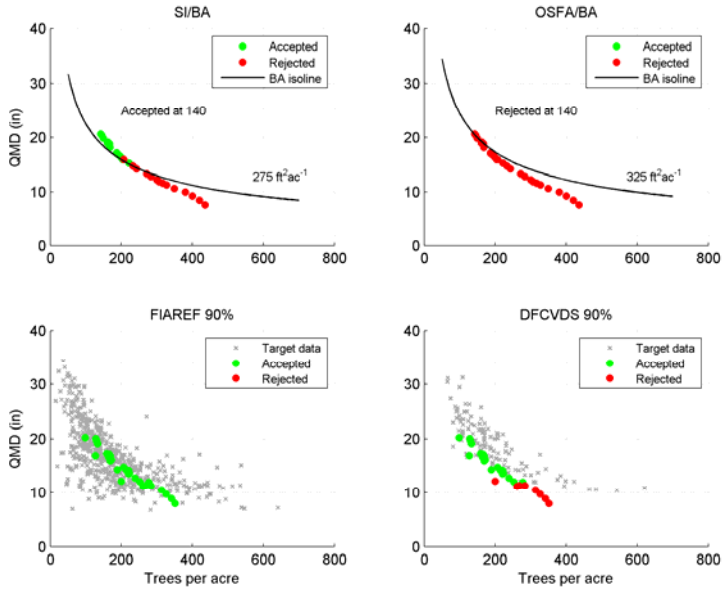
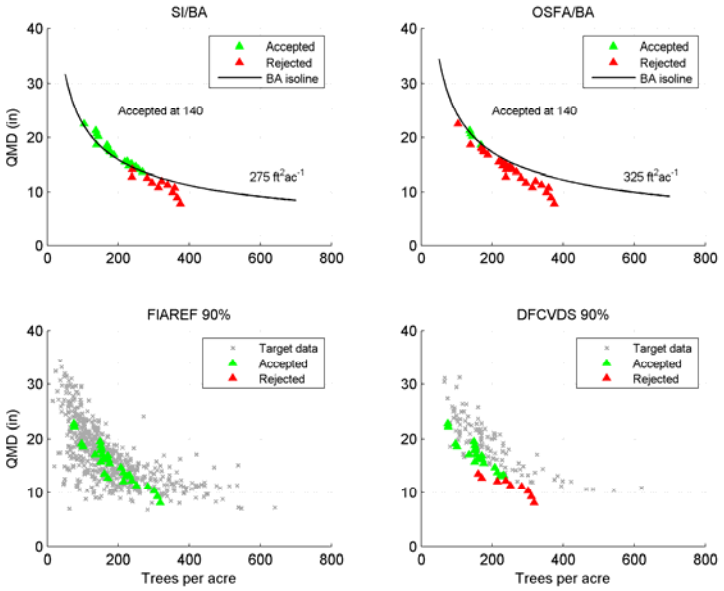
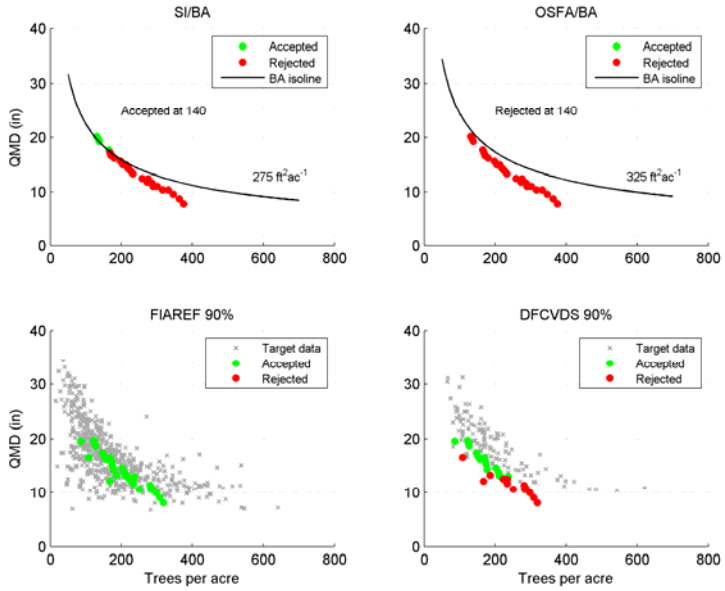


FF Option 2 < 10

O6.0

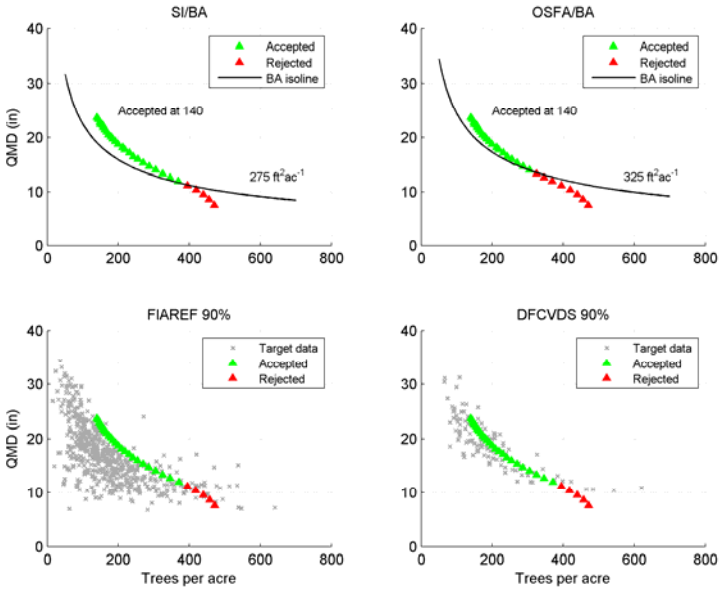


O8.2



No action

O6.0



O8.2